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REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION

HEARING

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

NINETY-NINTH CONGRESS

FIRST SESSION

ON

REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION

MARCH 20, 1985

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REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION

WEDNESDAY, MARCH 20, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee convened, pursuant to notice, at 9:32 a.m., in room SD-226, Dirksen Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to this hearing: Cassie Phillips, staff counsel and Pat Windham, minority professional staff member

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. The meeting will come to order.

The President's Commission on Global Competitiveness, in its January 1985 report, said that, and I quote: "Our ability to compete internationally faces unprecedented challenge from abroad. Our world leadership is at stake, and so is our ability to provide for our people the standard of living and opportunities to which they aspire."

The commission concluded that the United States is not meeting the competitive challenge. It recommended that we as a country do three things: first, create, apply and protect technology; second, reduce the cost of capital to American industry: and third, develop a more skilled, flexible, and motivated work force.

I regard these three recommendations as a charge to the Congress as well as to leaders in business, government, and academics across the country, to identify the restraints on American competitiveness, to find creative solutions to our problems, and to take action.

Today, we will focus on the first charge: to create, apply, and protect technology. This is a theme we will return to again and again in this committee. But today we start with the fundamental building block to developing our technology—basic research. And we start, appropriately, with the Federal entity with a unique mission of supporting basic research, the National Science Foundation.

I cannot overstate the importance of basic research as promoted by the National Science Foundation and its programs. It is the foundation upon which is built our economy, our standard of living, and our national security. I can think of few areas of our economy which are not touched by the benefits of scientific research.

Our oldest industries—farming, logging, shipping—are transformed by the benefits of research in chemistry, engineering, and astronomy. Our newest industries—biotechnology, advanced ceramics, and space transportation—are the direct result of basic research applied to practical commercial uses.

The National Science Foundation's budget reflects the importance of scientific research even in this year of fiscal restraint. Mr. Bloch has said that in setting priorities, he has increased programs which promote industrial competitiveness, support our science infrastructure, and are unique responsibilities of NSF.

I am pleased to see the support for engineering, especially engineering research centers; for advanced scientific computing, especially supercomputing centers for our academic community; for biotechnology, which is of considerable interest in my State; and for continued improvements in instrumentation and equipment.

Senator Riegle, do you have a statement?

OPENING STATEMENT BY SENATOR RIEGLE

Senator **Riegle**. Thank you Mr. Chairman.

Mr. Chairman. I am pleased to be back as ranking member of this subcommittee, and I look forward to working with Senator Gorton and other members of the subcommittee on this and other important issues.

The hearing today will focus on the operations and functions of the National Science Foundation. The budget that has been submitted proposes a $98 million increase in funding for the NSF to $1.6 billion, which is contrary to other areas of the nondefense research and development, where funding has been reduced. I concur with the proposed increase and view NSF as the lead agency in our efforts to maintain and enhance industrial competitiveness in the world markets.

I question the rationale for any reductions in the research and development support, in light of the report that has been issued by the President's Commission on Industrial Competitiveness. NSF is of particular importance to my State of Michigan. We are one of the top 10 recipients of NSF funding and received over $37 million last year in both research and fellowship support. These funds enable some very exciting research to be done at the University of Michigan, and Michigan State, and other locations; research that will be key to the development of new industrial processes and applications.

I am pleased to have such a distinguished group of witnesses before us, and look forward to exploring the issue of the proper level of Government-sponsored research and development.

Senator **Gorton**. Thank you Senator Riegle.

Senator Gore do you have a statement?

OPENING STATEMENT BY SENATOR GORE

Senator **Gore**. I am pleased that this subcommittee is conducting this authorization hearing on the National Science Foundation. Over the years, the NSF has performed an invaluable role in encouraging the development of science and technology in this country, and I have long been a supporter of its many programs.

I am deeply troubled, however, by the recent decision of the administration to eliminate one of the most important—and cost-effective—of the NSF's programs: the Ethics and Values in Science and Technology [EVIST] Program. The EVIST budget last year was only $1 million, less than 1 percent of the entire NSF budget, and a very small drop in the bucket of our current enormous Federal deficit. Yet, with only that small budget, EVIST has facilitated an invaluable examination of the ethical issues posed by the advancement of modern science and technology.

EVIST has unquestionably brought benefits to our society far greater than its cost and has had positive ramifications far beyond the specific projects it has funded. Its elimination would be a great tragedy and would be a classic example of being penny wise and pound foolish.

We live in a time in which science and technology are developing so rapidly that they are surpassing the ability of our social, ethical, and legal institutions to cope with them. New technologies are swiftly presenting us with questions that we are unprepared to answer and choices we are unprepared to make.

For example, the amazing advances in biotechnology are rapidly giving us the power to alter the genetic basis of life. Yet, we do not have a good grasp on how we will best use the technology and what limits may have to be placed on it. Moreover, as recent events with artificial heart transplants have demonstrated, we are acquiring the ability to sustain life in dramatic; new, and sometimes unorthodox ways. When is it appropriate to employ these devices and when is it not? And as we have seen with developments in reproductive technologies, we are approaching an era in which science can enable everyone to be parents through embryo transfers and perhaps even to preselect their children through freezing and storing embryos. There are significant benefits to be had from this technology. But there are also serious ethical questions raised by it.

Unless we begin now to search for solutions to the serious ethical dilemmas that modern science is creating, events will simply overtake us. We must make sure that we make the necessary effort to resolve those dilemmas in an educated and well-reasoned fashion. Without EVIST, however, there will be no coordinated Federal effort providing support for a systematic evaluation of these questions. Terminating EVIST thus is precisely the wrong thing to do at this time.

As a Member of the House of Representatives, I served on the House Science and Technology Committee for 8 years and chaired its Investigations and Oversight Subcommittee for 4 years. In that capacity, I chaired numerous hearings on technological advances and the challenges they pose for our society. Those hearings have left me unshakeably convinced that programs like EVIST must be preserved, and I intend to do everything I can to ensure that EVIST is saved.

Mr. Chairman, I am pleased that both Mr. George Keyworth, the President's Chief Science Adviser, and Mr. Erich Bloch, the new director of the NSF, are here to testify before us today. I hope that they will shed some light for us on the decision to terminate EVIST.

Mr. Chairman, Senator Hollings has a conflicting schedule and could not be here in person but has a statement for inclusion in the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. Chairman, never before have science and technology been so important to our nation's economic health and well-being.

In the years since World War II, American industries have seen their competitors on the world marketplace grow ever more aggressive. Foreign governments have adopted policies intended to give their industries a competitive edge—trade barriers, subsidies, and preferential loans, to name a few. In recent years, America has been losing the competition, especially in the area of manufactured goods. Just look at our soaring trade deficit if you want proof of this.

We can regain our industrial competitiveness, and we can do it without lowering our wages and our standard of living to match our competitors. The first step is to reduce our massive deficits, which, in turn, will bring down the dollar and make our products affordable overseas. Secondly, we must begin enforcing our existing trade policies.

But perhaps most importantly, we must work to preserve our technological superiority among world nations. Technology is and will be our competitive edge.

The President's Commission on Industrial Competitiveness (the Young Commission) stated the need well: "A technology gap is required--one in favor of the United States—both to maintain our standard of living and to provide an adequate national defense."

This morning we will hear from the President's Science Advisor, the new Director of the National Science Foundation (NSF), and the distinguished President of the National Academy of Sciences. I look forward to receiving their testimony and hearing their thoughts on how to strengthen the nation's science and technology base.

I also hope that the hearing will address several important issues. One is the Administration's response to the important recommendations made by the young Commission. I have heard very little comment from the White House on these matters—matters that I believe are essential to the country's future. Since Dr. Keyworth represents the White House today, and since he was a member of the Young Commission, I look forward to hearing whether the Administration will or will not accept the Commission's recommendations.

There is also the question of NSF's role in engineering. One major problem we have today is our failure to swiftly convert new discoveries into practical applications. This is tremendously important to our industrial competitiveness. NSF appears to recognize this in its budget request, in which funding for engineering has been increased. But the totals for this activity are still small, especially in the area of manufacturing. Unfortunately, no other agency in the Federal government funds research aimed at improving general industrial competitiveness. The Commerce Department steadfastly refuses to take the initiative in this area. I want to explore whether the Foundation is willing and able—within the limits of its charter, budget, and constituency—to do significantly more in engineering.

No one, least of all this Senator, wants to sacrifice important NSF science programs in the name of industrial need. But industrial need, particularly in the crucial areas of engineering science and generic technology, is great.

Finally, I hope that the Committee will address the question of "big science." This is an issue which goes beyond NSF and includes, in particular, the Department of Energy's large research projects. Research in astronomy, particle physics, and magnetic fusion is becoming increasingly expensive. The Senate Appropriations Committee, on which I serve, has begun to ask how much "big science" this country can afford. We are particularly interested in knowing which projects promise the best results and about opportunities for international cooperation.

Senator GORTON. Our witnesses today include Dr. Jay Keyworth, Mr. Erich Bloch, and Dr. Frank Press. Mr. Bloch, I would like to welcome you to your first appearance before this subcommittee and to congratulate you on receiving the National Medal of Technology.

In addition to the witnesses today, a number of statements have been submitted in writing and will appear in the record. Our first witness is Dr. Keyworth who, as always, is most welcome to the subcommittee.

STATEMENT OF DR. GEORGE A. KEYWORTH, SCIENCE ADVISER TO THE PRESIDENT, THE WHITE HOUSE

Dr. KEYWORTH. Thank you very much, Mr. Gorton.

I would like to read, if I may, an abridged version of my testimony and submit the entirety for the record.

Senator Gorton: We will be delighted to have you do just that. And your entire written testimony will be included in the record.

Dr. KEYWORTH. Thank you.

I am, of course, pleased to meet with you today to discuss the administration's policies and programs for science and technology. The National Science Foundation plays a truly vital role in the implementation of these policies, which I am sure will be evident in the presentation that NSF Director Erich Bloch will make to you today.

Mr. Chairman, the start of a new administration and a new Congress is an appropriate time to take stock and to chart a course for coming years. Many of our efforts are going to be concerned with critical choices we have to make in three areas. One is national security—how to create a more stable world and, specifically, how to reduce the presence of nuclear weapons.

A second is how we in America can insure our economic progress in the face of rapidly growing competition in the world's industrial markets.

And the third is how we can bring Government spending under better control and reduce the deficit that intrudes so rudely on our plans for the future.

Mr. Chairman, I think you will agree that our enviable lead in science is an important thread that runs through all of those issues—because science and technology are tools to forge our own destiny. They are our leverage on the future.

Fortunately, we go into the 1986 budget deliberations with our science and technology enterprise significantly strengthened over that of not many years ago. The growth of 55 percent in support for basic research over the course of these past two Congresses is restoring momentum to what is one of this country's greatest assets—our scientific enterprise.

In addition, and equally important, this high priority assigned to science by the Federal Government has elicited comparable high priority in the private sector for using that science. Industry has been increasing its rate of investment in research and development even faster than Government has, and in doing so it has also forged productive new partnerships with universities.

But here I have to interpose a cloud into that sunny picture; our science and technology present may be brighter than it has been in years, but a shining future is anything but guaranteed. Our leadership in science is fragile—extremely fragile. That should concern us deeply, because science plays the same role for technology as does a foundation for a house. Neither structures nor modern industry can exist without those bases of support. And today we depend—far more than most people realize—on our preeminence in science to enable us to exploit technology and to maintain our economic and national security.

Mr. Chairman, we are challenged this year to balance two dominant priorities. One is to permit investment in our future by reducing Federal spending. The other is to assure a strong national science and technology base. The budget being presented to the Congress does both.

Funding obligations for R&D will total $60 billion in fiscal year 1986; of that, some $20 billion will support non-DOD R&D, and $8 billion will support basic research. Funds obligated for non-DOD research and development will decrease slightly from 1985 to 1986, and funds for basic research will increase slightly above the freeze level. Within those proposed budgets I have no doubt whatsoever that we can conduct extremely effective R&D programs.

After 4 years of near-historic funding increases, there is momentum in the system to maintain healthy progress. Moreover, as a matter of practicality, actual outlays for basic research would rise by nearly 5 percent next year, which should even permit a little real growth. In addition, because we have deliberately postponed the start of construction for major new research facilities for 1 year, we will be able to maintain strong funding for ongoing research programs.

For example, when you examine the programs proposed for the NSF or NASA, you will find that there are adequate resources to support new high-priority programs. These include programs such as the new engineering research centers by NSF, launches of the space telescope and the Galileo mission to Jupiter by NASA, and advanced R&D by the Department of Energy on the continuous electron beam accelerator facility and the super conducting super collider. In light of the increased Federal support since 1981, there will be no threat to the health of U.S. science. I would even say that after such rapid growth, sharing in the overall Federal austerity may well stimulate sharper delineation of priorities for science.

I strongly support the necessity of slowing the growth of science and technology funding in the short term as part of the response to the deficit. But, at the same time, I won't hide my concern about the vitality of U.S. science over the longer term and about its continued attraction for the very best young minds. Even the most optimistic forecasters warn of several years of lean funding until we get the deficit to a level where it doesn't dominate Federal budgeting.

As I said, we are in good shape for 1986. Our real challenges will come in fiscal years 1987 and 1988, when we simply will have to find ways to ensure our ability to pursue—and pursue vigorously—new avenues of research. Progress in science won't stagnate—and it won't wait for us. Other countries, facing equally trying times, are renewing their support of basic science. And they are doing it in emulation of our own economic miracle. The last thing we want to do is to lose sight of our own successes and what stimulated them. So we will have to be prepared to make hard choices to fund new starts for high-priority research facilities under whatever fiscal scenario we face in coming years. What will be at stake will be the scientific leadership that we cannot afford to compromise.

And let me introduce a practical point here. As we focus upon fueling the engine of technology, there are two logical buttons to push—quality or quantity. Losers push the quantity button, and the engine sputters. Winners push the quality button, and the engine revs up. If we keep our eye on supporting quality, sufficient talent will follow to maintain our technological and scientific lead.

I raise this issue of quality as opposed to quantity because constraints on resources in coming years will continually challenge us to make wise decisions to preserve our leadership.

In terms of our immediate concerns, that means we have to make every dollar spent for basic research count. I said earlier that our budgets this year were adequate to do the job—but they are just adequate, and we cannot afford to let any of it get sidetracked on less than excellent programs. And that pressure to select among excellent programs will continue, perhaps even build, in coming years when it is imperative that we make room for new starts.

Mr. Chairman, let me quickly summarize the points I have tried to make here this morning. Our proceedings are dominated by a need for austerity, and we have responded to that need. Because of strong administration and congressional support over recent years, the programs for 1986 will enable American science to stay at the forefront. But our challenge is to make sure that our fragile scientific and technical leadership is not comprised—either by complacency on the part of others or by misallocation of limited resources by us. If we insist that we will be satisfied with nothing less than world leadership in those things we attempt to do, we can maintain the kind of healthy and responsive climate to continue to recruit the very best young minds into pursuit of science and technology, a recruitment that will serve the Nation well in coming years.

That concludes my prepared statement and I would be delighted to answer questions.

Senator GORTON. Dr. Keyworth, what will be the effect of the freeze on the National Science Foundation's appropriation, recommended by the Senate Budget Committee, if it becomes policy?

Dr. KEYWORTH. It will force us back, of course, from the present, very carefully planned, program and would put considerable pressure on some of the most important new thrusts. Since the Budget Committee action is very recent, I have not fully thought through the issue of where we would have to make decisions. I would emphasize that thrusts such as the Engineering Research Centers must not be compromised at any cost.

Senator GORTON. It will be very important to this Senator and this committee to have as detailed an analysis of what the impacts of that freeze are likely to be as we can before the next step is taken in the budget process. And that next step is likely to be fairly soon.

Dr. KEYWORTH. Mr. Erich Bloch and I will work together to ensure that you have that. It is certainly serious and we will try to quantify that for you.

Senator GORTON. Speak to me in at least general terms if you will about the relationship among various aspects of federally funded research, the National Science Foundation, and other civilian research. What degree of coordination is there with research done by the Department of Defense; how much of the research, either on the Defense side or the civilian side, finds its way through our universities to the private sector?

Dr. **Keyworth**. You referred in your introductory comments to the President's Commission on Industrial Competitiveness, of which I was a member. That was a central focus during the entire 18 months of our review.

Now let me try to put it in my own personal context and perspective. I think there is no question today that industry and the Nation as a whole see basic research exactly as you represented it—as the real cornerstone of our technological superiority. That is an important realization that has come to the forefront only in the last few years. The National Science Foundation, in the physical sciences and engineering at least, is the model for how we support and maintain that excellence. I put particular emphasis on that, well beyond even the considerable budget NSF funds. How are we seeing that affect other agencies?

Certainly the Department of Energy, in supporting many major facilities that academic research, responds to emphases in the National Science Foundation and I think that linkage is good. But I am deeply concerned about the effects of continually stoping these new facility starts. We simply cannot afford to compromise building those new facilities, in spite of budget austerity. I draw attention to the importance of the Superconducting Super Collider—a monumental accelerator facility—one that is mandatory if we are to accept nothing less than excellence.

Let's turn to the Department of Defense for a moment, as I think that is particularly important. The Department of Defense has worked very closely in a substantive way with the National Science Foundation, has explored carefully programs such as the engineering research centers and the Presidential Young Investigator Awards, and has put together a comprehensive package that begins—and only begins—to get it back to playing a serious role in the support of universities. I applaud the Department of Defense for the thinking it has done in the last 2 years. Its proposals to support universities and to strengthen their linkage are superb, and they are at the moment only token.

As the Department of Defense budget has increased to two-thirds of the total federal R&D budget, its support for basic research has not increased in a commensurate fashion. And since I referred to basic research as being the foundation of the house, I think that the foundation is not being strengthened in a commensurate fashion with the weight of the house.

Senator **Gorton**. Are you doing all you can to see to it that that foundation is strengthened?

Dr. **Keyworth**. Yes. Although I would never say I am doing all I can or enough, because we are not yet there. We held hearings in the House Armed Services Committee about 2 weeks ago in which this very issue was dwelt upon, but, Mr. Chairman, I mean to seriously emphasize my concern over this. The Department of Defense once supported the finest research ever performed in America. It built many of our great institutions. And I understand that times have changed, and the National Science Foundation is carrying on the tradition extremely well. But I am worried deeply about this link at a time when we are all concerned with defense spending, because in order to capture the leverage of defense technology, it is essential that we draw upon the best minds and the top talent in the country, and tomorrow's talent is all in our universities.

Senator GORTON. Will you tell me a little bit more about the Commission on Industrial Competitiveness on which you served, and be specific about what the administration will do or is likely to do to carry out its recommendations, and what you think we can most effectively do here in the Congress?

Dr. KEYWORTH. I, for one, believe that of the many reports that have come out on the state of American industry and competitiveness, all of which are good and important, this is the most comprehensive and the most profound. Within the administration, I know a number of people who are very prominent in the policy arena and who feel that this is a monumentally important report. There are certainly those who have concerns about particular areas but, in general, I think it is well recognized as being a first-class report.

How it is used and how it impacts our ability to target what the commission called a No. 1 goal—to raise the competitive spirit in America—will evolve before our eyes over the next 2 years. Right now, the central focus, as I think you realize even more intimately than I, is the budget and the deficit: How we are going to manage the central problem of spending the government's resources wisely.

Now how we respond to many of the long-term recommendations that are mandatory is yet to be seen. I would, at the risk of being presumptuous, hope that exploratory hearings will be held in the Congress with many of those outstanding people who took time from leading America's industries—trying to compete—and spent weeks and weeks working and probing the issue of competitiveness on that commission. They represent tremendous talent. As I have confessed to you that before, I found that a remarkable school. I learned a tremendous amount myself. I would recommend to the Congress as a whole that the talent, the wisdom, the advice, is well worth listening to.

I don't think it is something that can be implemented into law today, nor implemented into a budget today. I think it is definitely the problem from our end of the street for the next 4 years.

Senator GORTON. Thank you.

A couple of specific questions now. The Director and Deputy Director of NSF, as well as its 24-member National Science Board, are all appointed by the President and confirmed by the Senate.

Is it necessary or advisable to continue to go beyond that and have the Foundation's Assistant Directors be Presidential appointees as well?

Dr. KEYWORTH. I don't believe so. I think the National Science Foundation has more Presidential appointees than other agencies many, many times its size. Since I have been intimately involved in the selection of many of these people, I think the time consumed is counterproductive to maintaining the kind of aggressive NSF management that Erich Bloch and we all have wanted. It is a handicap right now, and I think it explains the long-term vacancies. Maintaining a Deputy Director and a Director as Presidential appointees, confirmed by the Senate, assures thorough and responsible management and control of the National Science Foundation.

Beyond that, the choice and selection of people should be worked out in a more expedient fashion than at present.

Senator GORTON. Last month the National Science Board released a report on the increasing tendency of educational institutions to bypass merit-based review through the legislative process. The report called on your office to join NSF to study the reasons behind the perceived need to bypass that kind of review.

Are you going to follow up on those recommendations?

Dr. KEYWORTH. We certainly are. We have a panel actively underway, under the chairmanship of David Packard and Allan Bromley, studying a simple question. We call it "The Health of University Study." And the charge that I gave them was to examine and make analyses and recommendations as to whether American universities are prepared to provide the kind of talent necessary to compete successfully in an increasingly competitive era, and they are doing exactly that.

Clearly there are serious problems pertaining to the health of our universities today. But I would not use that to excuse the tactics and techniques that have evolved in the last 2 years in universities to attempt to circumvent the normal review process. I think that is deplorable. I am not naive enough to say that I think it is shocking. Pork is not new in government by any means. But I think there is such a widespread sentiment within the scientific community that we are challenged, not in a way that we were 5 years ago, 10 years ago, 20 or 30 years ago—we are truly challenged today. Our leadership in science may not be there 5 years from today if we don't spend those dollars wisely.

And while we are sitting here talking about pork—and the science press is dominated by what is nothing other than the most blatant of pork—when I hear people saying that scientists have studied trough behavior for years. They say that scientists are the worst of all. I most certainly wouldn't make that statement, but I find myself very hard put to defend it. We have a problem. I do sympathize with universities, but this vestige of pork is the beginning of mediocrity.

Senator GORTON. Thank you. That is a very clear answer to the question, Doctor.

We have a few more questions for you which I guess, because of our time constraints today, we will submit in writing. They include questions from Senators Hollings and Riegle. As always, you are welcome to the subcommittee and I enjoy your messages. Thank you very much.

Dr. KEYWORTH. Thank you.

[The statement follows:]

STATEMENT OF DR. G.A. KEYWORTH II, SCIENCE ADVISOR TO THE PRESIDENT, AND DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY EXECUTIVE OFFICE OF THE PRESIDENT

Senator Gorton and members of the Committee, I'm pleased to meet with you today to discuss the Administration's policies and programs for science and technology. The National Science Foundation plays a vital role in the implementation of these policies, which I'm sure will be evident in the presentation that NSF Director Erich Bloch will make to you today.

Mr. Chairman, the start of a new Administration and a new Congress is an appropriate time to take stock and chart a course for coming years. Many of our efforts are going to be concerned with critical choices we have to make in three areas. One is national security—how to create a more stable world and, specifically, how to reduce the presence of nuclear weapons. A second is how we in America can ensure our economic progress in the face of rapidly growing competition in the world's industrial markets. And the third is how we can bring government spending under better control and reduce the deficit that intrudes so rudely on our plans for the future.

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Fortunately, we go into the 1986 budget deliberations with our science and technology enterprise significantly strengthened over that of not many years ago. The growth of 55 percent in support for basic research over the course of these past two Congresses is restoring momentum to what is one of this country's greatest assets—our scientific enterprise.

In addition, and equally important, this high priority assigned to science by the federal government has elicited comparable high priority in the private sector for using that science. Industry has been increasing its rate of investment in research and development even faster than government has, and in doing so it has also forged productive new partnerships with universities.

But here I have to interpose a cloud into that sunny picture. Our science and technology present may be brighter than it has been in years, but a shining future is anything but guaranteed. Our leadership in science is fragile—extremely fragile. That should concern us deeply, because science plays the same role for technology as a foundation does for a house. Neither structures nor modern industries can exist without those bases of support. And today we depend—far more than most people realize—on our preeminence in science to enable us to exploit technology and maintain our economic and national security.

Mr. Chairman, what I refer to as scientific leadership should not be confused with some kind of academic macho or with taller and more isolated ivory towers. When I refer to scientific leadership I'm describing our national creativity, our ability to be at the forefront of progress, and our ability to meet our responsibility as leaders of the free world. Two events during the past year brought home vividly to me the practical consequences of scientific leadership.

The first was my own experience serving on the President's Commission on Industrial Competitiveness—where I was a lone federal official in a group composed primarily of industrial leaders, few of whom share my technical background and biases for science and technology. Yet it didn't matter if they were bankers, labor leaders, seasoned heads of mammoth corporations, or young entrepreneurs—all agreed that in the international industrial arena, the United States has only two sustainable advantages over our competitors. Those two advantages are our technology and our talent.

Those industrialists understand better than most people how basic research fuels those two competitive advantages. They also emphasized that, just as they're responsible for maintaining our industrial base, which is fueled by our dynamic free enterprise system, that the federal government is responsible for maintaining our preeminent science and technology base—our fountains of new knowledge and technical talent. There was no doubt in the minds of these unquestionably "bottom-line" thinkers that scientific and industrial leadership go hand in hand.

My second observation of the essential role of scientific leadership is evidenced by the Soviet Union's response to the Strategic Defense Initiative, the President's proposal to use our scientific and technological expertise to develop defenses against nuclear weapons. It was the prospect that the United States would use our technological superiority to alter deterrence—and to diminish the Soviet strategic edge—that catalyzed the return of the Soviets to the arms control talks in Geneva.

The Soviets have more than one reason to worry about SDI. In addition to the prospect that strategic defense will make worthless the bulk of their immense offensive nuclear force, our effort to produce a defensive system will almost certainly stimulate a new thrust in technology and leave the stagnating Soviet economy yet further behind.

But here I must share my frustration. The Soviets recognize and justifiably fear U.S. science and technology. U.S. industry, facing a relentless challenge from other countries, especially Japan, places top priority on assuring a strong science and technology base to produce the knowledge and talent we need to compete. And the American people and today's students know instinctively how directly future economic progress and national security depend on our technological leadership.

As a scientist myself, I can be dismissed in coming before you touting the importance of science to our future. But we can't dismiss what we hear from the Soviets, from our industrial leaders feeling the hot breath of challengers on their necks, and from people across America; they have to be listened to. The President knows that science and technology have been the fuel for our post-war economic growth, yet too many of us in Washington take our preeminence in science and technology for granted. But the truth is that few of our great strengths are more fragile. Unless we recognize th vulnerable nature of this precious leverage, we may find the costs of complacency to be very, very high.

Mr. Chairman, we're challenged this year to balance two dominant priorities. One is to permit investment in our future by reducing federal spending. The other is to assure a strong national science and technology base. The budget being presented to the Congress does both.

Funding obligations for R&D will total $60 billion in fiscal year 1986; of that, some $20 billion will support non-DOD R&D, and $8 billion will support basic research. Funds obligated for non-DOD R&D will decrease slightly from 1985 to 1986, and funds for basic research will increase slightly above the freeze level. Within those proposed budgets I have no doubt whatsoever that we can conduct extremely effective R&D programs.

After four years of near-historic funding increases, there's now plenty of momentum in the system to maintain healthy progress. Moreover, as a matter of practicality, actual outlays for basic research would rise by nearly five percent next year, which should even permit a little real growth. In addition, because we've deliberately postponed the start of construction for major new research facilities for one year, we'll be able to maintain strong funding for on-going research programs.

For example, when you examine the programs proposed for the National Science Foundation or NASA, you'll find that there are adequate resources to support new high-priority programs. These include programs such as the new Engineering Research Centers by NSF, launches of the Space Telescope and the Galileo mission to Jupiter by NASA, and advanced R&D by the Department of Energy on the Continuous Electron Beam Acclerator Facility and the elementary particle Superconducting Super Collider. In light of the increased federal support since 1981, there will be no threat to the health of U.S. science. I would even say that, after such rapid growth, sharing in the overall federal austerity may well stimulate sharper delineation of priorities for science.

Mr. Chairman, dealing with budgets necessarily immerses us in what I would call the tactical problems of individual program priorities. Those are the practical steps we have to take to turn policy into reality. However, I also want to urge us to stand back this year and do some extra strategic thinking about science and technology. I say that because I see the central challenge we face as preserving our fragile scientific leadership.

There are two things we have to do. First, we have to embrace our responsibility for basic research. Basic research is as essential to our two highest priorities—maintaining economic growth and national security—as is any other investment we can make today. I won't deny I'm concerned about our ability to sustain the kind of leading-edge basic research program this country absolutely must have. We can't take it for granted. We have to convince others of its importance, and we have to make sure that the current priority for basic research is maintained.

Second, we have to make every dollar count. Science and technology are dynamic processes, kept alive by a constant input of new energy, new people, and new ideas. The worst danger we face is to be lulled into complacency about our leadership and fail to allocate funds wisely. Yes, the United States spends more than $100 billion for R&D in the public and private sectors each year, far mroe than any of our industrial competitors. And, yes, we have an almost unbroken record of success in amassing prizes for research. But, again, look at American industry and see how a history of success and domination of the marketplace was challenged almost overnight by determined competitors. We who bear responsibility for the readiness of American science better learn from that experience.

I strongly support the necessity of slowing the growth of science and technology funding in the short term as part of the response to the deficit. But at the same time I won't hide my concern about the vitality of U.S. science over the longer term and about its continued attraction for the best young minds. Even the most optimistic forecasters warn us of several years of lean funding until we get the deficit to a level where it doesn't dominate federal budgeting.

As I said, we're in good shape for 1986. Our real challenges will come in fiscal years 1987 and 1988, when we simply will have to find ways to ensure our ability to pursue—and pursue vigorously—new avenues of research. Progress in science won't stagnate—and it won't wait for us. Other countries, facing equally trying times, are renewing their support of basic science. And they're doing it in emulation of our own economic miracle. The last thing we want to do is lose sight of our own successes and what stimulated them. So we'll have to be prepared to make hard choices to fund new starts for high-priority research facilities under whatever fiscal scenario we face in coming years. What will be at stake will be the scientific leadership that we can't afford to compromise.

We've seen in the past what can happen when even very strong science and technology enterprises are prevented from following up on new discoveries. One example that this Committee is familiar with was the apparent impact on space sciences of the unanticipated high costs to develop the Space Shuttle. In spite of our virtual ownership of the western world's space program in the 1960s and 1970s, we nevertheless find ourselves seriously challenged for leadership in some fields that we had pioneered, and we face the 1990s with no assurance that we'll be able to regain the momentum that we had made the down payment for in fields like x-ray and infrared astronomy and solar physics.

In coming years we can foresee similar forks in other scientific paths. For example, the nation—or group of nations—that builds the superconducting super collider will become the new world center in high-energy physics. I won't conceal my opinion that it would be a serious blow to U.S. scientific leadership if that facility were built in another country, because a place like that is a magnet for talent and creativity. A big accelerator involves far, far more than the relatively small number of people who can work directly with it, because it stimulates interest in science and excellence far across society and because it inevitably spins off new ideas and technologies.

In the near term our success in providing several new research facilities, such as the Tevatron I and II and the Stanford Linear Collider, puts us in a strong position to maintain our leadership. But we're on notice that over the long haul the leadership in high energy physics is up for grabs. The recent stunning success of a European team working at CERN in Switzerland in detecting the Z-nought particle was the most important advance in a decade, and it quickly brought the Nobel Prize to the team's leaders. That's a very real reminder that our many years or leadership in that field are, right now, being aggressively challenged.

Likewise, we'll be faced very soon with decisions about proceeding with construction of two forefront research facilities for nuclear physics—the continuous electron beam accelerator in Virginia and the relativistic heavy ion facility, whose initial options are being developed at Brookhaven National Laboratory. Nuclear physics, a field of immense productivity in earlier years, is about to re-emerge as one of the most exciting areas of research into the structure of matter, and we have a well-timed opportunity to lead the rest of the world here too.

And we could go on. Will we reassert our leadership in materials science and begin building such next-step facilities as the synchrotron radiation source recently recommended by the Seitz Committee of National Academy of Sciences? Or do we let the Europeans steal a march on that discipline, a discipline that's becoming critical to advanced technologies in a broad range of modern industries. Someone is going to come up with the next-generation equivalent of microelectronics or recombinant DNA, and I want that someone to be an American. That's not jingoism—it's realism. And it's the spirit of healthy competition that we have to take to heart.

And how will we respond to emerging opportunities in, say, the life sciences? One concern I have is that much of the enthusiasm for funding of the NIH comes from concern for specific diseases, rather than from enthusiastic appreciation of the basic science by which diseases are cured. Consequently, we now see an imbalance in funding approach—a "disease-of-the-month" mentality driving the funding and setting the priorities for one of the most exciting frontiers of science, namely, the biological sciences. It's important that agency missions be supported by strong basic research in those disciplines related to them, whether those missions are health or space or defense. But a mission will be met more effectively by addressing the discipline. For example, it was basic research that found the cause for AIDS. And it will be basic research that will cure cancer. I also worry that funding that's driven mainly by mission is an inefficient approach. It presumes a wisdom that man does not possess, a wisdom that runs counter to our experience that we're very smart when it comes to *doing* researach and very dumb when it comes to predicting where the profound applications will be. Our current system of funding most of the biological sciences because of a presumed relationship to a disease is little more than bureaucratic convenience; it's *not* the way to sustain leadership in an increasingly competitive age.

The biological sciences stand on a brink of understanding that I can only liken to the brink that Einstein saw for physics in 1905. So it's fair to ask if we *are* developing the science base we need to reap the benefits that we foresee. Or will we, by remaining captive to past successes and hamstrung by a system of research support inadequately suited to the opportunities ahead, deny our people the advances in medicine and in new industries that others will capture by moving boldly ahead?

One thing to keep in mind is that one can pursue frontier life sciences research on a far smaller scale than is required in most of the physical sciences. It wouldn't surprise me to find newly industrializing nations, looking for opportunities in science and technology, to develop strong capabilities to challenge us in biotechnology. Yet we seem to be giving far too little attention to protecting and capitalizing on our long-term investment in life sciences by broadening the disciplinary base.

Another area of fragility shows up when we fail to maintain a consistent policy to respond to emerging frontiers. Young people have the best noses for tomorrow's hot areas of research, but their career choices can be constrained by prospects for support for research. Uncertainty about support—the kind of uncertainty that results from start-and-stop funding—will effectively chase them away from a field, and maybe chase them away from research careers altogether. As you've heard me say on many other occasions, students are unquestionably our greatest resource, and our country is the loser if we fail to attract the best young minds into science and technology.

Last year, for the first time in many years in the United States, the number of applicants to engineering schools grew while the number of applicants to law schools declined. I've joked with some of my lawyer friends that we could call those relative enrollment trends a "Competitive Index" and use it as a positive indicator of how our society is recognizing and responding to competition from other industrial nations. We have the momentum with us now. It would be a shame if that index again turned negative because we failed in our responsibility to maintain a climate to attract our top minds to science and technology.

And let me introduce a practical point here. As we focus upon fueling the engine of technology, there are two logical buttons to push--quality or quantity. Losers push the quantity button, and the engine sputters. Winners push the quality button, and the engine revs up. If we keep our eye on supporting quality, sufficient talent will follow to maintain our technological and scientific lead.

I raise this issue of quality as opposed to quantity because constraints on resources in coming years will continually challenge us to make decisions to preserve our leadership. I'm especially concerned about our ability to make long-term plans for the future and carry them out in a timely manner. Science is an often tediously methodical process requiring long preparation. Smaller research facilities may take four or five years to plan for and bring on-line. Major facilities, like a space telescope or a next-generation elementary particle accelerator, can take nearly a generation from inception to completion. It's our mutual responsibility to ensure an optimistic and visionary climate, the American climate, in which scientists and engineers can conduct this sensitive process of planning and bringing on line the tools needed for tomorrow's R&D.

Recently David Packard, a man I consider to be one of our great Americans, observed to me that there are some very close parallels between success in industry and professional sports. He said that three factors determine success. One is the technical skills of individuals, which means that you can't even get started without the basic training and experience. But basic skills are essentially evenly distributed among teams, as they are among competing companies. So the other factors make the difference in the outcome of competition. One is the individuals' zeal to win, and the other is how well thay work together as a team. Well, Coach Packard has a pretty good won-lost record over the years, and I'd sure want him in my locker room at halftime. So I'm inclined to take his observation seriously. Happily, in the past few years we've seen a strong rejuvenation of that zeal to win in America, A reaction to the international pressures we've felt on all sides. But we haven't come nearly far enough in developing the kind of team spirit that we also need.

My object in relating this story is to reinforce two points. First, we can't play the industrial game unless we have the technical skills and zeal to surpass our competitors, and that brings us right back to the need for a strong basic research environment—the spawning ground for ideas and talent. And second, we need better teamwork. We need to build on the collaboration that's emerged between the Administration and the Congress with regard to priority for science and expand it to include academia and industry too—with all accepting responsibility for making sure we nurture those technical skills and carry them into practice. In terms of our immediate concerns, that means we have to make every dollar spent for basic research count. I said earlier that our budgets this year were adequate to do the job—but they're just adequate, and we can't afford to let any of it get sidetracked on less than excellent programs. And that pressure to select among excellent programs will continue, perhaps even build, in coming years when it's imperative that we make room for new starts.

Sidetracking is an occupational hazard in Washington. We've all felt pressures to support projects in which something other than pur excellence was the driving criterion. Those pressures emerge naturally from our political system, a system that tries to accommodate local interests and national objectives. And we'll find, frequently, that the scientists themselves lack national perspectives, and their advice may be unclear. But let's at least say to each other that we'll do our best to resist those distractions and that we'll focus our attention on those steps necessary to advance our scientific leadership.

Mr. Chairman, let me quickly summarize the points I've tried to make here this morning. Our proceedings are dominated by a need for austerity, and we've responded to that need. Because of strong Administration and Congressional support over recent years, the programs for 1986 will enable American science to stay at the forefront. But our challenge is to make sure that our fragile scientific and technical leadership isn't compromised—either by complacency on the part of others or by misallocation of limited resources by us. If we inisist that we'll be satisfied with nothing less than world leadership in those things we attempt to do, we can maintain the kind of healthy and responsive climate to continue to recruit the best young minds into pursuit of science and technology, a recruitment that will serve the nation well in coming years.

This concludes my prepared statement. I would be pleased to respond to questions from Members of the Committee.

(The following information was subsequently received for the record:)

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. Section 303 of P.L. 94-282 calls for a Federal Science, Engineering, and Technological Survey. This section has not been implemented, according to a 1980 GAO study. Do you plan to issue this report, as required by statute? What kind of long-range planning is OSTP doing?

Answer. Executive Order 12039, dated February 24, 1978, transferred responsibility for implementing Section 303 of P.L. 94-282 to the President, who delegated the science, engineering, and technology functions to the Director, Office of Science and Technology Policy. The survey specified by Section 303 is a one-time activity. However, most of the issues to be addressed by the survey require continuing attention. This attention is being given by the Administration and is manifested in many actions already taken or currently underway. The review of Federal laboratories by the White House Science Council in 1983, the Council's current study of university research, and the National Science Foundation's ongoing study on technical manpower are examples. These types of activities are also part of OSTP's long-range planning since they lead to policy formulation which has impacts many years in the future.

Question. I understand the biennial report required by the National Science and Technology Policy, Organization, and Priorities Act of 1976 has been delayed for several months. Why has the Office of Science and Technology Policy not published this report?

Answer. The next biennial report required by the National Science and Technology Policy, Organization, and Priorities Act of 1976 will cover the calendar years 1983 and 1984. We expect agency inputs early in May and will plan to issue the report by the end of June 1985.

QUESTIONS OF SENATOR HOLLINGS AND THE ANSWERS

PROGRAMS TO SUPPORT INDUSTRIAL COMPETITIVENESS

Question. The Administration says that it opposes anything that smacks of "industrial policy," by which I infer any government efforts to "target" specific industrial areas. Last year, for instance, the President pocket-vetoed this Committee's manufacturing sciences bill, claiming it was "industrial policy" even though it simply would fund unsolicited proposals on manufacturing issues.

Yet NSF has now chosen to fund new work in engineering. The Commerce Department is now trying to fund a new industrial research effort in ceramics. You yourself have initiated efforts very much targeted towards aiding two new industries—advanced materials and biotechnology. NASA's Ames Research Center has a new program aimed directly at helping the domestic aircraft industry.

I am not criticizing these efforts. This Committee believes in prudent partnerships with industry to develop new technology in economically strategic areas. But I see an obvious gap between the Administration's rhetoric and actions.

What is the Administration's policy here? Do you favor research aimed at helping specific sectors or do you not? And given the veto of last year's bill, why do America's important manufacturing industries rank so low on the Administration's list of R&D priorities?

Answer. The government's primary responsibility in supporting industrial competitiveness must be to create an economic climate where productive investment and risk-taking are encouraged and rewarded.

Recently, the President's Commission Industrial Competitiveness recommended that, in order to make technology a continuing competitive advantage for the United States, the Federal government, industry and our universities need to do three things: create a solid foundation of science and technology relevant to commercial uses; apply advances in knowledge to commercial products and processes; and protect intellectual property.

The Administration has taken its mandate in this context to be first and foremost the strong support of basic research, particularly at universities. Our responsibility is to ensure the necessary supply of fundamental knowledge, generic technology and trained minds that industry will need to develop world competitive applications of that knowledge and technology.

Thus, unless the government will be the ultimate user of a technology (as, for example, in defense applications), I do not believe that it is appropriate for the government to try to compete with the private sector by developing commercially oriented products or processes. Nevertheless, by encouraging more partnerships among the universities, the private sector, and the Federal government, we have sought to channel more federally-funded fundamental research into commercially relevant areas. Our support for materials research, engineering research centers, supercomputer access and aerodynamics research are just a few examples of our support for such research programs.

I did not support last year's manufacturing technology bill because of a lack of definition of its scope, and because it would have placed responsibilities on the Department of Commerce that, in my view, were unwarranted and redundant. Similar activities are already underway in slightly different forms in the National Science Foundation. I was not, however, opposed to the stated intent of that bill.

Question. In all of your statements, you stress that the Federal government's role is in basic research. Certainly we would agree that product development is the province of private industry. Yet in between basic research and commercialization is a grey area known as "generic" research, the development of new basic processes, materials, and non-proprietary prototypes. The United States lags Japan in this area; it is one of the major reasons why American companies have such trouble at converting scientific discoveries quickly into new products and processes.

What is the federal responsibility in "generic" technology, especially in the case of new or fragmented industries where companies cannot afford to develop these basic inventions by themselves? Which Administration programs support the development of generic technologies?

Answer. The successful translation of fundamental research results into commercial products requries close coupling between the researcher on the one hand, and the engineers and marketing people of the product divisions on the other. This is going to take major changes in attitude and behavior in universities, government and industry. We can no longer afford the luxury of treating each other as adversaries, but must work together much more closely than has been the tradition in this country. I believe that this is happening, and the Administration's support for: the NSF engineering centers; DOE, DOD and NSF programs in materials research, and advanced computer research; and the new DOD university research initiative; are a few examples of programs designed to support the development of generic technologies.

ENERGY RESEARCH

Question. Recently yet another scientific review panel endorsed the Continuous Electron Beam Acceleration Facility. You yourself have endorsed this relatively lowpriced project for research in nuclear physics. Yet the Department of Energy has provided no construction funds for the project in its FY 1986 budget request.

Does the Administration intend to fund this machine or not? If so, why has funding been delayed? If not, why have you changed your mind?

Answer. Scientists within the basic nuclear research community have identified the need for a high energy, continuous electron beam accelerator capability. A review panel chaired by Professor D. Allan Broomley of Yale University was first to endorse this machine in a report dated April 1983. Recently, an NSAC subcommittee reaffirmed the priority for this machine in a report dated September 1984.

The Administration continues to support the Continuous Electron Beam Acceleration Facility (CEBAF) and that support is reflected in the budget request for FY 1986 as submitted by DOE.

Quoting from DOE's submission:

"In FY 1986, $5,000,000 in operating expenses is requested to continue research and development and A/E activities to better define the CEBAF project's scope, schedule, and total cost. The objective of FY 1986 work is to establish a technical base for this project so that construction could be initiated in FY 1987."

Question. Large machines for both high-energy physics and magnetic fusion are becoming increasingly expensive. Last year, Members of the Senate Appropriations Committee asked the Administration to list its priorities in these two expensive areas and indicate the opportunities for international cooperation and cost-sharing.

Have you reponded with a clear set of priorities in these two areas? If not, when will we receive them? In an age of tight budgets, can the United States continue to fund these large machines entirely by itself?

Answer. To maintain the state-of-art research in high-energy physics and magnetic fusion, large and expensive machines are necessary. In recognizing this requirement, this Administration has proceeded with caution requiring detailed justifications and efficient management decisions prior to undertaking these large and expensive projects.

Listing the efforts presently underway:

A. High-Energy Physics:

1. Detailed research is required before going forward with a large financial commitment to the Superconducting Super Collider (SSC). DOE has requested this research funding in FY 1986 to resolve some of the unknowns in the SSC design before contruction is undertaken.

2. DOE and OSTP, last year, requested the Nuclear Science Advisory Committee to again review the value of the Continuous Electron Beam Acceleration Facility (CEBAF), before going forward with this major effort. NSAC concurred with the priority of CEBAF and DOE is now going forward with the facility.

3. This Administration is going forward with the recommendations of the Seitz report on Major Facilities for Material Science.

B. The fusion program has now completed the construction of the TFTR fusion machine at Princeton. The machine has operated and presently is being improved with additional neutral beams. In addition, DOE continues with construction of a comparatively large machine at Livermore (MFTF-B). The fusion community has been working for several yeras on preliminary designs for the next major machine; one to reach a "burn" condition. DOE and the fusion community recognize that budgets are tight and this next machine must be cost-effective.

Through these examples, the Adminstration has given its priority on the next major facilities it faces. In addition, the cost-benefit of each machine is constantly being evaluated. Thus, the Administration continues to set priorities in tight budget times.

Finally, the issue of international cooperation is extremely relevent. DOE and OSTP have had numerous discussions with Europe and Japan on how to cooperate on both our existing programs and on future machines. I look forward to greater cooperation in these area with our international partners.

NATIONAL SCIENCE FOUNDATION

Question. This year NSF proposes to cut its policy research program by more than half and completely eliminate the small ethics and values activity. The Committee recognizes that NSF's main mission is to fund scientific research and that these programs have been cut in the interest of strengthening research.

However, who in the federal government will now be responsible for studying the enormous policy and ethical implications of our national investment in science and technology? Will your Office of Science and Technolgy Policy take on this responsibility? Do you have the resources to do so?

If your office does not have the resources, where will you turn for policy advice on science and technology? Will we find ourselves committing more funds with less understanding of their effects and efficacy?

Answer. The Federal government's own studies of science policy and the ethical implication of those policies and practices have never been a major factor in either the Executive or Legislative branches' decision making. I believe that these activities are best carried out by independent organizations and widely published and discussed by all interested parties. This is a function in which our press and academic communities have always played a major role. OSTP does not have either the resources or the appropriate vantage point to undertake much of this task.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

THE PRESIDENT'S COMMISSION ON INDUSTRIAL COMPETITIVENESS

Question. The findings and recommendations of the President's Industrial Competitiveness Commission (the Young Commission) are of great interest to this Committee, including their conclusions that (i) there is not enough Federal research and development with competitiveness as its goal and (ii) manufacturing technology needs more emphasis.

As both a high ranking Administration official and a member of the Young Commission, you are in a unique position to comment on the Commission's report.

Will the Administration adopt the recommendations of the Young Commission? Will it propose a new Federal Department of Science and Technology, as the panel recommended? If not, what steps will you take to ensure that the Federal government's huge R&D program is more oriented towards the needs of all of American industry—both new sectors and traditional industries that are modernizing?

Answer. The Administration certainly concurs with the general thrust of the Report of the President's Commission on Industrial Competitiveness. The Cabinet Council on Commerce and Trade devoted four of its meetins to examining the Commission's recommendations and is now preparing a report for transmission to the President suggesting which of the Commission's recommendations should be targeted for implementation.

Independent of the Commission's report, the philosophy of my office has been to encourage the federal funding of basic research and to develop ways for federal/industry partnerships to be created to address the needs of American industry. My staff, for example, is working with the steel industry, the non-ferrous metals industry, and the off-road machinery industry in exploring joint research ventures between industry and federal laboratories. In addition, we have strongly supported the Engineering Research Centers funded by the National Science Foundation which are designed to bring industry, university and federal resources together to attack technical problems of critical importance to industry, while at the same time training new students and providing incentives for the retention of engineering faculty. My office will continue its work to make sure that federal research expenditures benefit all of American industry to the maximum extent possible.

The Commission's proposal to establish a Department of Science and Technology is under active consideration both by the Administration and by the outside technical community. Frankly, given our current concerns over the budget deficit, the issue of establishing a Department of Science and Technology may not be resolved in this fiscal year.

Question. The Young Commission recommends that the current R&D tax credit be extended and in fact expanded. The Administration has endorsed extension. Yet Professor Edwin Mansfield and others have questioned whether this expensive tax break has indeed produced much new industrial R&D. There are also reports of abuses, including one unconformed story that McDonald's applied the credit to the development of "Chicken McNuggets."

Why does the Administration support extension of the credit? Do you support its expansion to cover additional R&D-related expenses? What empirical evidence do you have that the credit has actually increased industrial R&D investment above what it would otherwise have been? Does the credit benefit only large companies and not smaller, high-tech firms who do not earn enough to pay taxes or claim the credit?

Answer. The Administration last year sought a three-year extension of the R&D tax credit. The key function of a tax credit is not just to increase aggregated R&D funding, but to emphasize the benefits of long-term industrial commitment to research, and to encourage greater industry linkages with the research community, particularly at our universities.

Recent studies by the Congressional Research Service, and by Data Resources Incorporated for the Coalition for the Advancement of Industrial Technology, suggest that a research tax credit can be justified, although not necessarily exactly as it is now enacted. Senators Danforth and Bensen, and Congressmen Pickle and Frenzen have also proposed amendments to the R&D tax credit legislation, while making it permanent. These studies and proposals suggest that a permanent tax credit should emphasize research rather than development, encourage industry sponsored university activities, and expand the coverage of research to include some areas, now excluded, that are clearly appropriate (e.g., software).

The R&D tax credit is an issue that requires some careful study in light of Mansfield's and the more recent studies. I expect to discuss it in detail with Treasury over the next several weeks.

BUDGET AND PROGRAM PRIORITIES

Question. The President requests an overall increase in research and development funding for FY 1986. Yet nondefense R&D actually would fall under this Budget. The military share of the Federal R&D would rise to an unprecedented 72 percent. With the exception of modest increases at NSF and NASA, most civilian R&D declines. Even agencies of proven benefit to industry, such as the National Bureau of Standards, are cut.

All of us support our nation's defense. But given your statement's emphasis on enhancing economic competitiveness, and given the Young Commission's call for more, not less, R&D oriented towards industry, how do you explain these budget priorities? Is there not a gap between the Administration's rhetoric on economic strength and its actions?

Answer. There is no inconsistency between the R&D priorities expressed in the President's FY 1986 Budget, and the recommendations of the Young Commission for enhancing our economic competitiveness. It is a question of priorities in a time where our overriding concern for enhancing competitiveness and national security must be to reduce our deficit. Consequently, the President's nondefense R&D budget focuses on basic research in the physical sciences and engineering, which continues to show real growth. The Administration is encouraging greater university-industry cooperation to orient university research towards industry needs. This is at the continued expense of development programs, especially in DOE, that actually reduce incentives for commercialization by private industry.

Question. This year the Stevenson-Wydler Technology Innovation Act is up for reauthorization. The act has three main parts: a Commerce Department office to track trends in technology (now proposed for elimination); a Commerce Department program to help fund centers for generic industrial R&D (never implemented); and a requirement that Federal laboratroies help transfer their technology to the private sector and states.

Will the Administration request the reauthorization of the Stevenson-Wydler Act or any part of it? Why or why not?

Answer. The Administration fully supports the intent of the Stevenson-Wydler Act. I believe that many of its specific provisions, however, are misguided and would, if fully implemented, be counterproductive, especially to the extent that they persuaded people that the government "was taking care of the problem" and everyone else could now ignore it. As one example, it is widely agreed that technology transfer is difficult to ensure, even within the best run companies. It is also agreed that people exchanges are by far the most effective mechanism. The Administration has sought to encourage much greater personnel interchange between universities and industry; among Federal laboratories, the universities and industry; and between the government and industry. The requirement of the Stevenson-Wydler Act requiring Federal labs to establish an Office of Research and Technology Applications is based on a model of technology transfer which holds that technology is a reservoir, which can be tapped and siphoned as needed. In my view, far more effective commercial use of Federal lab technology would result from amending rules and regulations which discourage industry scientists from taking positions in Federal labs, or from Federal labs working freely on cooperative projects with industry. The Stevenson-Wydler Act served to focus attention on a national problem, but it has been overtaken by events and the Administration will not request its reauthorization.

Senator GORTON. Mr. Bloch.

Once again, welcome to the subcommittee for your first visit. We will be happy to listen to your presentation. Your entire written statement will be included in the record as if read, and you may summarize it, please.

STATEMENT OF ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Mr. BLOCH. OK, thank you, Mr. Chairman, for your welcome and for your congratulations. I also want to thank you for supporting in the Senate Budget Committee the President's request for the general science and space budget. We appreciate that very much.

Senator GORTON. It was a lonely group.

Mr. BLOCH. I understand that, and I hope, however, that it will succeed in the end. We depend very heavily, obviously, on the budget that we have submitted.

I will be very short in my prepared remarks, to give you more time for questions.

Mr. Chairman, this is a very tight budget year. We have fared well in the considerations leading up to the President's budget submission to Congress, which speaks well of the administration's and hopefully Congress's continued support for the U.S. scientific enterprise.

Nevertheless, we had hard choices to make, and choices reveal much about one's priorities. Our first priority is to maintain and improve, where possible, the health of basic scientific and engineering research.

We also realize how important basic scientific and engineering research is to U.S. industry, in helping it to stay ahead of its international competition, to avail itself of new processes, materials, and equipment, and to stay ahead of rapid advances in new and emerging technologies. Also, through research, we educate and train young scientists and engineers for industry, for government, and for faculty in universities. So this is our first priority.

These concerns led us to give priority to three major areas in developing the 1986 budget. First, we increased support to programs that are most directly related to economic competitiveness. The first one is engineering, for example, which is the key to converting scientific progress and technological breakthroughs into products and processes. The new engineering research centers, in particular, have that mission and goal in mind.

Engineering, as a consequence, is up about 13 percent, to $170 million in this budget request.

For similar reasons, significant increases are planned in biotechnology, Earth sciences, and advanced materials. Especially, the latter is of ever-increasing importance to both established and emerging industries.

Second, we will continue to improve the infrastructure of science at universities. This includes people, equipment, and facilities that are integral to the conduct of research, and the particular priorities are people first, equipment and instrumentation next, and facilities third.

Through research grants, we are supporting over 14,000 graduate students and postdocs, a 4-percent increase over last year. In addition, we support over 1,500 graduate fellowships and 500 Presidential young investigators. Support for instrumentation is up 15 percent to over $270 million, a trend that I will discuss shortly in somewhat more detail.

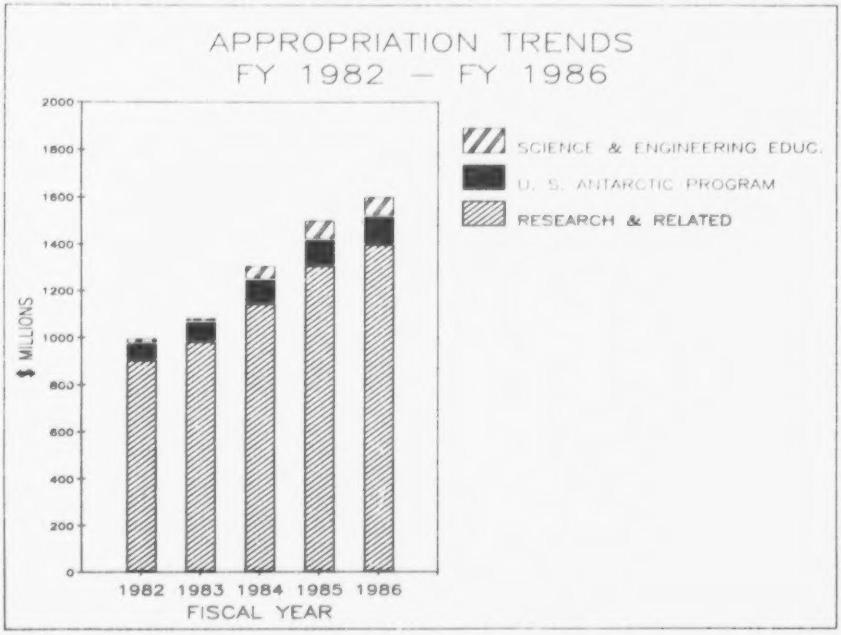
Facilities such as the recently announced supercomputer centers and the engineering research centers [ERC's] will provide stimulating research environments for a large number of academic researchers.

The third area of our priorities involve those activities for which NSF has a special responsibility because it is a major source of Federal funds or a major source of funds in general. Activities such as core mathematics, environmental biology, and social and economic sciences received substantial increases for exactly these reasons.

Now, given these priorities in an austere budget year, we had certain other decisions to make. We are curtailing certain programs no longer in the mainstream of scientific and engineering research or of secondary priority. We are stretching out large capital investments, and lowering adminstrative costs.

Of course, we are continuing a strong effort to leverage funds by increasing participation and cooperation among universities and industry, such as in the Presidential young investigators and the engineering research centers programs. This is a new trend, this cooperation, and I think it is a good trend. The Foundation has to do its part to lead that and make sure that it continues.

Now, let me look at the budget in a little more detail and discuss the 1986 budget request in conjunction with previous years' budgets.

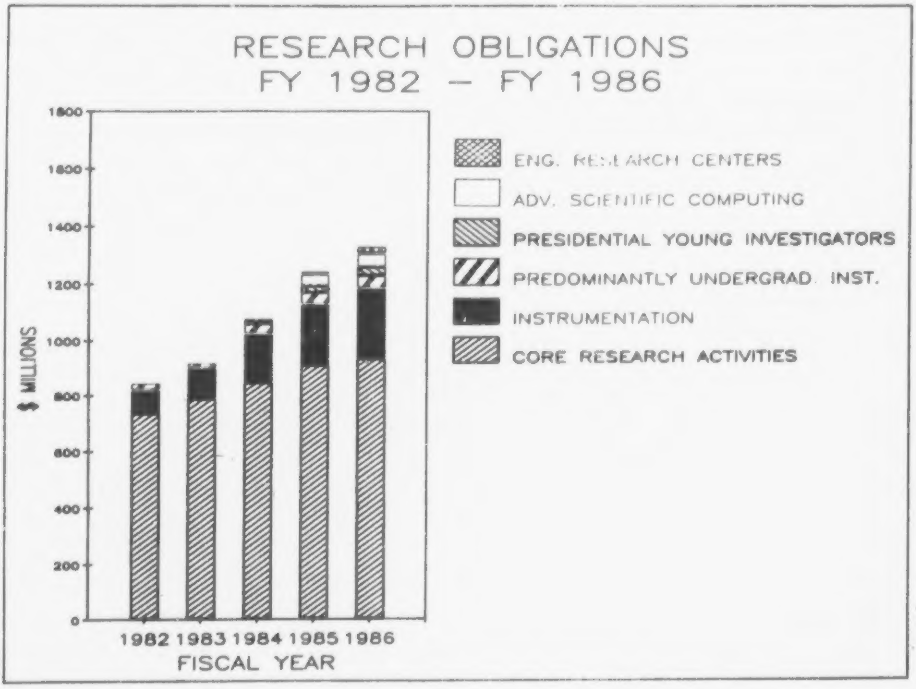


The first chart that I am showing you on the screen gives the appropriations obligated for the 1982-86 time period. They have fared very well, mostly due to strong support by this administration and this committee for basic research. Since 1982, the research and related activity—the green line—is up about 54 percent, from $900 million to about $1.4 billion.

The U.S. Antarctic Program is up about 75 percent in the same timeframe. And the science and engineering education area is up about 292 percent, from about $20 million to $82 million in this same timeframe.

All major research areas shared in the increases, in that we have maintained core research activities in addition to emerging research opportunities. The Antarctic Program has grown because of our central role in coordinating all research activities in the Antarctic. The NSF is responsible for funding and managing the U.S. Antarctic Program. I need to point out that most of the funding, about 90 percent, has gone for equipment and facilities in that region.

After many ups and downs for the science and engineering education area, we are now building a solid foundation, especially for the precollege activity. We can discuss this later.



The second point I want to make is shown in more detail by examining the components of the research and related activities. Again, I am showing the 1982–86 timeframe. Core research, in red, is up 27 percent. Core research is a dynamic assembly of programs. We took a hard look at these programs as part of the 1986 budget preparation and reduced or terminated funding for programs that are no longer competitive.

With the freed-up funds, we have provided for exciting new research opportunities in areas such as biotechnology, materials research, and the new ocean drilling program. We will continue to make these evaluations and hard decisions, to assure Congress, this committee, and ourselves that the best and the most promising research opportunities are properly funded.

Instrumentation, the next line up there, is up 200 percent, to $271 million. That is about 20 percent of our total research-related expenditures, a bigger number than we ever had in the past, and it probably will increase over time.

Several initiatives are started and are well underway, and we are supporting them in this request. The support to predominantly undergraduate institutions is aimed at 4-year institutions, and it is up 76 percent, to $44 million in 1986.

The Presidential Young Investigator Awards will increase to $30 million, providing support for 500 of the Nation's finest young Ph.D.'s. The positive influence on SEE decisions, I think, can be seen by very personal experiences. Whenever I go to a university, I meet with the Presidential young investigators, and the question I usually ask is: What would you have done without this particular program? And many times I get the answer: We would have gone into industry, and therefore deprived the faculty of very important support, or we might have done something else. But many times you hear the answer that, without this program, it would have been a tough decision for a young investigator to stay in a university.

Advanced scientific computing, the green area, has been increased to $46 million. It provides scientists and engineers with access to supercomputer centers. We recently announced four center awards for Illinois, Cornell, the University of California at San Diego, and Princeton. A fifth one, using a NASA computer provided by Congress, is under discussion with Carnegie-Mellon.

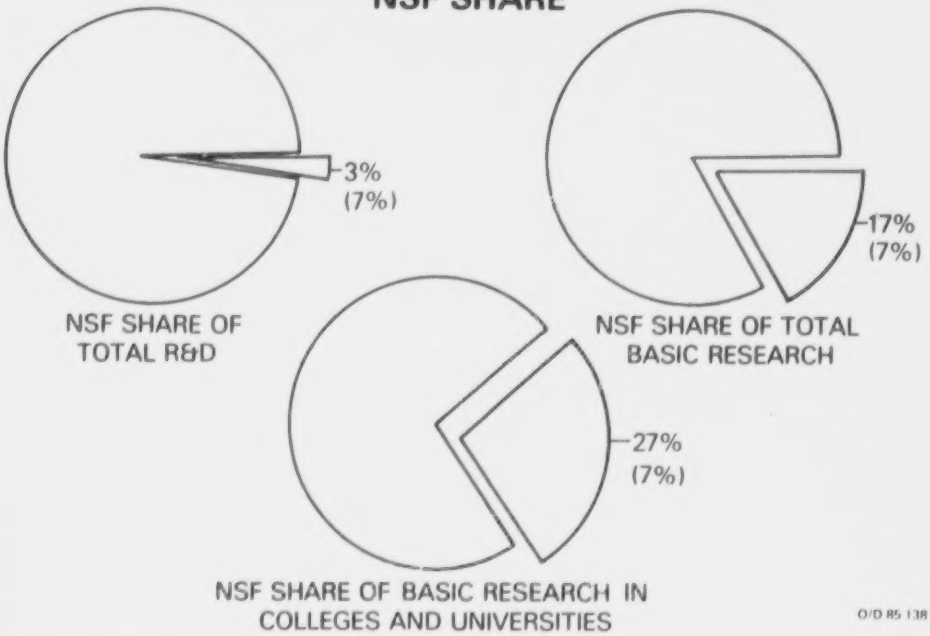
The engineering research centers [ERC's], the last item, will climb to $25 million, which is a $15 million increase over 1985. And between 1985 and 1986, we will try to support approximately 10 engineering research centers.

We received many requests for the centers. When we went out with the solicitation, we received 142 proposals. Through the peer review process we have narrowed them down to the point where we will be ready in the next couple of weeks to announce the first five or six centers.

The interest generated suggests that even unsuccessful applicants will use the ERC model in their own limited way and in their own environment.

FEDERAL SUPPORT FOR CONDUCT OF RESEARCH AND DEVELOPMENT, FY 1986

NSF SHARE



The last point I want to make is to compare NSF with the total Federal support of R&D. NSF is only about 3 percent of that total budget, a very small amount. But NSF's share of the total basic research is 17 percent, and if one looks at the NSF share of the basic research in colleges and universities, NSF represents about 27 percent, a very significant amount.

That ends my discussion. Let me just summarize, Mr. Chairman, for a minute. Much thought has gone into this particular request. As a result, it represents a balanced and integrated approach between single investigators and large facilities. It is a balance that we always have to strike and that we have to strike anew every time between human resources and equipment, as I tried to make clear, and between traditional research activities and critical emerging areas.

We believe this strategy is essential for maintaining and improving an increasingly complex scientific enterprise. It is a strategy that speaks to the future and not just to the present or the past. The idea is that the people and equipment that we support today will provide the scientific and engineering leadership of tomorrow.

I respectfully ask for this committee's support for our programs and budget. Thank you very much.

Senator GORTON. Thank you, Mr. Bloch. I am going to start you with the same question with which I started Dr. Keyworth, and that is to comment on the effect of the freeze voted by the Senate Budget Committee on the National Science Foundation, if it in fact survives through the budget process.

Mr. BLOCH. Well, it would have a very detrimental effect. And let me just make a couple of points on that. First, the 4-percent increase, that we got on the bottom line, is really rather minimal. But we were able, by making some internal rearrangements, by looking very hard at some of the functions that have been in existence for some time, to give about a 7-percent increase to the research areas.

That 7-percent increase helped us greatly to fund the new initiatives in a significant way. That is very important. If we did not have the 4-percent-bottom-line increase, many of these initiatives would have been underfunded significantly. I think it is important that one maintains the dynamics of those new initiatives in such a way that they are meaningful and that results appear quickly.

The Engineering Research Centers initiative is one of the examples. If it takes us 10 years to put these Engineering Research Centers in place, we will miss great opportunities. And that is why the focus is on them.

Supercomputers represent another example. They are not inexpensive. You need to have the capabilities and the facilities to make these work in the same way. So I think what this budget increase, small as it is, provided for us was essentially capability to fund new initiatives. If this were frozen at the previous levels, we would have to go back and really reexamine these particular funding areas and see how much we would have to reduce them.

Let me just make a second point. Our priority, as I pointed out, was people first—protecting people, protecting their research, and making sure that we attract people to science and technology and engineering. That is our highest priority, and that would still be the highest priority, even if there were a freeze.

The second one was instrumentation, because without instrumentation, not much research can be done, or research will only be done in an ineffective and mediocre way. But there is no doubt that the second priority probably would have to be reduced if we are faced with a budget freeze. So instrumentation would be one of the first areas that would suffer from it.

Last, but not least, some of our big capital investment programs that have already been stretched out and probably would have to be looked at in very critically to see how the stretch-outs could be obtained.

So my first priority would be to protect research and the people in particular. Next, I would probably do something with the instrumentation area, reduce it significantly, look at the new intiatives and see how much they could be reduced, and last but not least, look at the capital investment areas—large capital investment areas in addition to instrumentation—and see how those could be reduced.

Senator GORTON. Thank you.

Another question similar to that which I asked Dr. Keyworth. It appears that some of the senior staff positions at the Foundation which require Presidential appointment have been vacant 2 years or more. Has this disabled the National Science Foundation in its pursuit of its goals? And, in your view, is it necessary that those positions be filled by Presidential appointment?

Mr. BLOCH. Well, this particular subject was a great frustration to my predecessor, Dr. Knapp, and it is becoming a great frustration to me. I think it has hurt the Foundation tremendously. I cannot imagine that any industrial company would leave major positions, vice presidential positions in research, development, manufacturing, or anything like that, open for 2 years without going bankrupt.

The Assistant Directors are the key to the Foundation. They really control what happens on a day-by-day basis. They make the decisions in their respective areas of research.

I do not believe that making these positions Presidential appointment positions adds anything to them in terms of prestige or whatever you might want to consider. But I think it detracts from rapidly filling these positions, and I would really urge the Congress to look at this particular area and see how we can get out of it.

I am pretty sure that the original idea was well-meaning but it has not worked out that way.

Senator GORTON. We will look into that question.

Unfortunately, Dr. Schmitt, the Chairman of the National Science Board, could not be here today in person. He did, however, give us a statement for the record, and makes a good case for an amendment to the Organic Act of NSF which would enhance the Board's oversight role by removing the dollar cap on awards which can be delegated to the Director.

Dr. Schmitt argues that the Board could then concentrate on issues of greater policy significance. How do you feel about that proposal?

Mr. Bloch. Well, I am in full agreement with that. I have looked at this particular problem, together with Dr. Schmitt. If you review what kind of programs had to be reviewed by the Board itself over the last couple of years, you come to the conclusion that it is a very small percentage of the totality of the programs in the National Science Foundation.

Second, it is very unevenly split because it is really a random event. It depends on the award size, rather than on the problem that a particular award represents. And, as a consequence, much time is spent on what I call very minor awards, small awards, and some of the big issues fall by the wayside.

So I agree fully with Dr. Schmitt's request that the dollar value be removed and that the Board be given the responsibility to delegate to the Director whatever it considers the right level to be. The Board can always remove that delegation, so there is no problem in terms of giving too much control to the Director. What the Board gives one day, it can take away the next day. So I am in full agreement with Dr. Schmitt.

Senator Gorton. Would you explain the National Science Foundation's role in international science policy and whether there are any dynamics or changes taking place?

Mr. Bloch. Yes; I think there are a great number of dynamics taking place. In fact, when I first came to the Foundation, I decided that we needed another look at a strategic approach to international science.

The things that are changing are many. First of all, competition in international science is increasing all over, not just in industry, and as a consequence there are many able programs and projects going on around the world. Second, there is an increase in the cost of science. Especially, there is an increase in the facility costs, and sharing some of these facilities is probably the right thing to do, not only on a national scale, but also on an international scale, wherever that can be done. Ocean drilling is one example of a high capital investment area where international cooperation can help greatly.

The third point is that I think the programs that should be handled on an international scale are more massive than they were in the past. Also, they are more interdisciplinary, and we should take advantage of that.

Last, but not least, I think that the Foundation has done well in the international science area. It was primarily aimed at bilateral activities, and I think we now have to look at international science in the multilateral sense, like we did in ocean drilling and like we did in Antarctica. But I think that applies to many other areas.

As a consequence of this, Dr. Guy Stever has been asked to head up a committee, which is just now reporting back, to look at this problem for the National Science Foundation. This committee would examine where we should go strategically, how we should accomplish it, and what the content should be.

When that is completed, which it will be in a few months, I will be glad to report back to you on it.

Senator Gorton. Please do.

No money was appropriated for this fiscal year to implement the Math Science Act. But I would still like your response about how that act has been received and whether or not it ought to be amended because of the similiarities between its programs and your existing science and education programs.

Mr. BLOCH. Yes; you are right in stating that there were no budget allocations for that particular act. Obviously, we have looked at the act, and we have analyzed it very carefully and very thoroughly. There are many things in the act that are in line with what we are doing in the Foundation this year in 1985 and next year in 1986.

The emphasis on partnerships, for instance, among universities, local and State governments, I think is important, and we are doing that. The stress on improving cooperation between departments of mathematics and science and departments of education is another point of agreement.

The emphasis on providing services to segments of the population who are underrepresented is another area of agreement. But, in addition to that, the act has very special and very specific kinds of provisions in it that would be very difficult to implement, and would also be counterproductive, in light of our efforts in the science and engineering education area. For instance, a very precise description of cost sharing, I think, is something that we could not implement very well.

So we have a lot of problems with the act in the specifics. We don't have any problems in some of the general areas. And we have made our views known.

Senator GORTON. This year the administration included the so-called engineering amendments in its draft reauthorization bill, which we backed last year. As the new Director, what is your view of these amendments?

Mr. BLOCH. We are resubmitting these same amendments. I am in favor of the amendments. They are very timely and they are very good. They probably don't change very much the complexion of what goes on within the Foundation. But I think they give us essentially a reminder for the future that engineering and science have to be looked at together. So I am very much in favor of those amendments.

Senator GORTON. What is the Foundation's long-range plan for its supercomputer initiative?

Mr. BLOCH. As I mentioned before, we have already announced four centers. We probably, over time, will go or should go to about 10 centers—that is a very imprecise number—to be able to cover the requirements that the community in total will have in the future for supercomputers services and the dependency it will have on supercomputers. So establishing the centers is priority No. 1.

But then comes priority No. 2, which is equally important. In this particular area, like in many of the other science and engineering areas, the rapid change, the rapid development, and the rapid innovation in supercomputers makes it very important that we upgrade these centers over time. If you leave a center for 3 years without upgrading it, I think it will be obsolete in 5 years.

So we need to continuously upgrade it. That is strategy point No. 2.

Point No. 3 is also very important. The supercomputing center should not exist as a self-contained entity. You need access to it. In fact, we want to have the supercomputer centers interlinked with each other, so that one can share resources. One can make the best machines available to those areas that need it the most; share the resources, share the availability of time and, at the same time, by this interlinking, get some kind of a community going that exchanges programs, exchanges results, and exchanges activities.

In fact, we probably should think in the long haul of an international network that interlinks supercomputers in this country with some European universities. Europe today has put in place supercomputer centers and is interlinking them on its own. We are doing the same here and interlinking the two networks is probably a very wise thing to do in the future.

The whole area of communication is also a changing area, and we have to make sure that we avail ourselves of the best technology when we put these networks in place. In the beginning, it will depend on existing networks. Over time we will evolve to more advanced networks.

That is our strategy.

Senator **Gorton**. Mr. Director, as you see, we have been rejoined by the ranking member of the committee and by one of our newest members, Senator Gore. Senator Riegle, now I will defer to you for questioning.

Senator **Riegle**. Thank you, Mr. Chairman.

I want to welcome Mr. Bloch here. I am always glad to see another former IBM employee, as I am myself. And I am also pleased to see that we now, for the first time, have an engineer heading the Foundation, which I think is an important step.

I had hoped earlier to address some questions to Dr. Keyworth, and I will do for the record, but I am wondering—I am sure you have had the opportunity to read the President's commission's "Report on Competitiveness." I think it is a stunning piece of work, very important in its implications, unanimous in its judgments, a commission appointed by the President, this President, including his science adviser. And they paint a fairly stark picture in terms of the erosion in our competitive position.

And one of the facts they relate in their document is that Japan, for example, a country smaller in population than ourselves, is graduating twice the number of engineers presently than we are here in the United States. I find that very disturbing. And I am wondering about your reaction to that. What does that mean, not just today, but sort of looking ahead in terms of our ability to solve complex technical problems and maintain and enhance our competitiveness and so forth?

Mr. **Bloch**. Thank you, Senator Riegle.

I didn't have the pleasure to know you when you were in IBM, so I am glad to make your acquaintance now.

By the way, I am not the first engineer to head the National Science Foundation, but I am the first engineer from industry.

Senator **Riegle**. I see. Well, so much the better.

Mr. **Bloch**. Thank you.

Let me answer your question in a direct way. I have been looking at that problem for a long time. When I was in industry, obviously, it concerned me greatly because it was my responsibility to look at the science and engineering human resources that IBM had. And it was always somewhat of a puzzling question, why Japan graduated that many more engineers per capita, twice as many as in the United States.

I never have found a very good answer. But let me make the following point. I think over the last 7 or 8 years, the engineering enrollment has increased significantly in the United States. For a long time it was very flat, and then all of a sudden, in 1975, it started to increase, so that between 1975 and 1984 we probably had about a 70- to 80-percent increase in enrollment, which is very significant.

The problem that we have now is essentially that the enrollment is leveling off, and it is being driven by a couple of things; first of all, by the birth rate of 20 years ago, or 18 years ago. That certainly has an effect. But it is also driven by the faculty shortages in universities. Universities have put a cap on their engineering departments, and that is very disconcerting.

So I think we do have a problem. I hope that our engineers, and I know that our engineers are better educated and better trained than the Japanese engineers, but you can't rest on that. That is a questionable statement. No. 1, and No. 2, there is great emphasis in Japan to revamp their undergraduate engineering system in total. But I think it should be a concern to us.

I also hope that some new tools, which engineers design and come up with every day, like design automation systems, for instance, are going to help us to improve the productivity of our engineers. That is one way of stretching, essentially, the supply. But I think we should look at it with great concern.

I do not think that it is absolutely important that we match on a per capita basis exactly what Japan does, because our environment is different; as I said before, our education system is different. The way people are used in industry is different over here. The way people are used in research in general, not just in industry, is different over here. But still, the leveling off process that we are seeing after a big spurt over the last few years should give us concern.

Senator RIEGLE. Well, just extending that a bit, I take Japan as a specific example because of the tremendous commercial success and economic success that they have achieved. Obviously, one of the components that has drive has been concentration on specific objectives driving the education system and the applied technology system and so forth.

As I look around the Pacific basin, it looks to me as if other nations are wisely intending to copy the Japanese model. I don't want to suggest in any way that this is a one-nation problem because it is not, and it is to their credit that they have been able to marshal themselves and move at that rate.

I am concerned that we are not moving at a sufficient rate, and the President's commission indicates that. Would you give me your impression of the overall strength of our engineering education system and the degree to which it is absolutely up to date in terms of its technical strength and equipment and other things? In our engineering education system across the United States today, both at the undergraduate and graduate levels, how do we stack up? Are we where we should be, or are we behind the curve in terms of adequate faculty, adequate resources, adequate equipment? Where do we stand? I mean, give me the bottom line, and then you can elaborate on it. But how do we look today in terms of our overall engineering education capability in this country?

Mr. BLOCH. I think we look better today than we looked 5 years ago, but we are not looking as good as we should.

Senator RIEGLE. Well, take the second part, the not looking as good as we should.

Mr. BLOCH. Let me take the second part directly. The universities, in particular in the engineering area, have a major problem. The problem is engineering today is done differently than engineering was done when I came out of school 30 years ago, and it differs in a very fundamental way. It is no longer just experimentation or experiments. It is essentially modeling and simulation, which take the place of experiments, and this means the use of computers and other kinds of things. That is point No. 1.

Point No. 2 is that the whole instrumentation area in the universities has not kept up with modern instrumentation. That is not only true in engineering; that is equally true, maybe more true in science. So that is the second problem.

The third one is a little more profound and also more difficult to deal with. Engineering is today becoming more and more interdisciplinary. It is no longer mechanical engineering over here and electrical engineering over there. But these areas need to interact because the problems of today are primarily system problems. They are not individual design problems. They exist, too, but that is not where engineering is really leading or where it should be going.

So this interdisciplinary approach to engineering is kind of foreign to universities. It is well known in industry because the problem dominates. In universities, the discipline dominates. We have to change the universities around to this new approach. The engineering research centers, which we discussed before you came in, really have that particular function in mind. Through engineering research centers we bring this message home to the universities, and more importantly, give them the capability of moving into this new way of doing engineering.

Senator RIEGLE. If you were to take point B, the equipment and the technical capability in simulation machines and so forth that you spoke about, what would be your very rough estimate as to what it might cost us as a nation to bring our engineering schools across the country up to the level they should be, just on the equipment side?

Is that a $10 billion bill, or a $1 billion bill, or $500 million, or what might it cost to do that?

Mr. BLOCH. Yes; something like that.

Senator RIEGLE. Which end of the range?

Mr. BLOCH. Obviously, the numbers are very difficult to come by. But let me give you a point of reference. Each engineering research center will cost us about $10 million over 5 years.

Senator RIEGLE. $10 million?

Mr. BLOCH. Yes; $10 million over 5 years for one engineering research center.

Senator RIEGLE. Well, that is not an awful lot of money in a trillion dollar budget.

Mr. BLOCH. No; it's not, but if you multiply it by the number of universities that should have an engineering research center, you get a fairly high number.

Senator RIEGLE. Well, it sounds to me, though——

Mr. BLOCH. It is within the realm of possibility, if that is what your concern is.

Senator RIEGLE. Yes; well, what I am trying to get to is that we need to begin to talk in terms of doing what needs to be done, and I think we ought to lay out the scale of the problem. We ought to lay out the resources that are needed to bring us up to where we should be, and then that is what we should talk about. That should be the agenda.

If we are only talking about nickel and diming on the margin, when we are basically out of phase with meeting a much larger challenge, then I think we will probably fall further behind. We are not making relative progress. So what I would like to suggest to you is that I think it would be constructive to try to size up that problem in terms of how much money it might cost, and then we could think about where it comes from. Obviously, some would properly come from the Federal Government and perhaps some could come from private industry and maybe we could have other sources. Maybe it will take a combined way of doing this.

But the concern that I have is that we are just making small dents in a big problem here; and all of the available data that is accumulating, including the President's Commission, suggests to us that we have got to make a substantial leap. We have to jump over a series of obstacles. To do that, as in the space program or anything else where you make a national decision to accomplish something, you focus a lot of effort and a lot of resources over a fixed timeframe. You may cover 10 years in 3 years, in other words, if that is your goal.

Mr. BLOCH. May I just add one point?

Senator RIEGLE. Yes, please.

Mr. BLOCH. 1 or 1½ years ago, there were estimates around on the total instrumentation problem in universities. They included more than engineering; they included science and engineering, and represented estimates of the requirements for upgrading to state-of-the-art instrumentation. The total for all the universities ranged from $1 billion to $10 billion.

Senator RIEGLE. $1 billion to $10 billion?

Mr. BLOCH. $1 billion to $10 billion. Take the middle ground of that, about $5 billion. That's to upgrade it.

I want to suggest another thing. Today, instrumentation gets obsolete after 3 years, so you have a replacement problem of about 30 percent per year, and we are far from that particular range in what we are doing in the Foundation today. Even so, we are doing quite a bit, and as I mentioned before you came in, about 20 percent of our funding goes into instrumentation. But it is not enough.

Senator RIEGLE. It seems to me, though, we are going to have to make a decision as a nation, because the world has changed and world economic relationships have changed. If we want to stay in the ball game, and if equipment has a 3-year life cycle, it means that we are going to have to decide whether we want to get into that game, stay in that game, protect our living standard, protect our national security interests here and around the world by having a system that can move as fast as anybody else's. I would like to see us talking about that, rather than getting trapped in back and forth discussions on a very scaled-down effort that is designed to do important work, but basically just scratches the surface of a much larger problem.

And I would like to see us get the dimensions of that larger issue out there before people. I think the public, if they could sit through a debate that laid this out in an understandable form, would agree to spend something on the order of $5 billion every 3 years to upgrade; in other words, to make the jump up to the present standard and then stay there.

You know, that is a fraction of the cost of the MX missile system which we decided to go ahead with yesterday, which we dare not use. We are going to build it, and, we are going to build it so that it will not have t be used. And what we are talking about here is equipment that would be used and gives you a payoff down the line.

I want to ask one other question in an unrelated area, and then I will yield. I thank the chairman for the time here. While the ERC budget increases from $10 million to $25 million, you do not propose any increase in the older program of industry/university cooperative research centers, and a sharp cut in the related university/industry cooperative research projects.

Given the strong emphasis on economic competitiveness, and given the success of these cooperative research programs, why are these budget proposals being made?

Mr. Bloch. Well, first of all——

Senator Riegle. Where are we going in this area? What do you see down the road here?

Mr. Bloch. You should know that we have just transferred the IUC's, Industry/University Cooperative Centers Program from the STIA directorate into the engineering directorate, so that they are coupled closer to engineering, because about 85 percent of those centers are engineering-oriented anyway; and second, so that they are coupled much closer to the engineering research centers and to the activities that are going on there.

So I didn't feel it necessary to increase the budget in this particular area at all because of the sharp increase that we have in the engineering research centers. Putting them under one management will give us some benefits anyway in terms of efficiency, but also, more importantly, they are going to be looked at now in a more coherent manner.

IUC's serve one particular purpose. They are very narrowly oriented centers, which you know very well, as they should be, because they are trying to solve a particular problem. Engineering research centers are really very broadly oriented centers.

But between the two of them, I think we can find the right balance, and that is why I didn't feel it necessary to increase the IUC's, whereas I found it necessary to get something started in a significant way in the ERC's. If we had had more money, probably we would have done something.

It was again a question of priorities and the new initiatives. The engineering research centers being one of the foremost initiatives were given the maximum possible to get them off the ground. Those were the reasons, and they are not very profound.

Senator RIEGLE. Well, I have taken my time. I will have some additional questions for you for the record.

Senator GORTON. Thank you.

Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman. I appreciate the chance to participate in this hearing and I, too, am apologetic that I missed Dr. Keyworth. I will also submit some questions in writing for him.

I agree with everything that my colleague from Michigan has said, and these concerns must be addressed. I want to focus on one particular matter that has not been discussed, to my knowledge, during the hearing. And it is something that I am very troubled about. And that is your decision, Mr. Bloch, to completely eliminate one of the most important and cost-effective of NSF's programs, the Ethics and Values in Science and Technology Program.

I served for 8 years on the House Science and Technology Committee, and for the last 4 years chaired the Investigation Subcommittee there. A great deal of our time was spent investigating the new questions arising in bioethics, new questions provoked by advances in fields of science across the board.

Now, this is a very small program, only $1 million, less than 1 percent of the entire NSF budget. Yet, with only that small budget, this program has facilitated an invaluable examination of the ethical issues posed by the advancement of modern science and technology. The program has unquestionably brought benefits to our society far beyond its cost, and has had positive ramifications far beyond the specific projects that it has funded.

Its elimination, in my view, would be a tragedy and a classic example of being penny-wise and pound-foolish.

We live in a time when science and technology are developing so rapidly that they are surpassing the ability of our social, ethical, and legal institutions to cope with them. New technologies are swiftly presenting us with questions we are unprepared to answer and choices we are unprepared to make.

For example, the amazing advances in biotechnology are rapidly giving us the power to alter the genetic bases of life. Yet, we do not have a good grasp on how we will best use the technology and what limits may have to be placed on it.

Moreoever, as recent events with artificial heart transplants have demonstrated, we are acquiring the ability to sustain life in dramatic, new, and sometimes unorthodox ways. When is it appropriate to employ these devices and when is it not? And, as we have seen with developments in reproductive technologies, the subject of a cover story in one our news magazines last week, by coincidence, we are approaching an era in which science can enable everyone to be parents through embryo transfers and perhaps even to preselect their children through freezing and storing embryos.

There are significant benefits to be had from this technology, but there are also serious ethical questions raised by it.

I am dumbfounded that against the backdrop of these enormous dilemmas for our society, that with discoveries from the scientific journals on the evening news on a nightly basis, that against this backdrop one of your first decisions would be to completely eliminate this program.

This decision is opposed uniformly by the scientific community. Scientific societies have taken formal positions against your decision here. The American Academy for the Advancement of Science, Electrical and Electronic Engineers, Society for Computer Simulation, American Philosophical Association, Association of American Universities, and hundreds of individual scientists have written Members of Congress.

Members of the National Science Board were not consulted about the decision. In my opinion, it is a very serious mistake. Unless we begin to search harder for solutions to the serious ethical dilemmas that modern science is creating, events will surely overtake us. We must make sure that we have the necessary effort to resolve those dilemmas in an educated and well-reasoned fashion.

Without this small program, however, there will be no coordinated Federal effort providing support for a systematic evaluation of these questions. Terminating the Ethics and Values in Science and Technology Program, thus, is precisely the wrong thing to do at this time.

Why did you do it?

Mr. BLOCH. Thank you for your question.

I will be glad to answer it as best I can. I probably won't satisfy you, but let me try.

Senator GORE. Oh, you may. Just say, "I made a mistake: I am going to recommend that we put the money back in."

Mr. BLOCH. It is not that simple, Senator. Let me be very forthright about it. As you said yourself, this is a very small program. It lives in isolation. It is a $1 million program. It is very important to certain people, and it is very important to certain groups, and I understand that.

And you got a large number of letters apparently, Congress did, and so did I. I have probably received 100 letters by now. I haven't counted them of late.

Let me tell you exactly what went through my mind. Then you can judge if it is as irrational as it seems on the surface.

It is a program in isolation. It has done a lot of good things. It has established a lot of activities that are going to live, with or without that particular program. Some journals in this particular area of ethics and values in science were funded initially by this particular program.

Senator GORE. And they have been cut off now.

Mr. BLOCH. They are self-promulgating today. And that, by the way, is a credit to the program; that it was capable of doing that.

Senator GORE. One of many.

Mr. BLOCH. The second point is that we have a big program in behavioral and social sciences, and I think the same kind of proposals that come into this particular program can flow in there and be judged in conjunction with all the other things that are coming in that area.

The third point, on which I don't want to leave a wrong impression, is that this program was not specifically concerned with what is normally called risk assessment in biological sciences. We have a very strong program in that area. We are going to continue that program. In fact, we are augmenting that program.

All the issues that you cited that are coming about by the revolution in biological sciences are essentially of concern to the Foundation and are being treated in our biological, behavioral, and social sciences directorate. So you are linking too many things into this particular program.

I can assure you that the risk assessment area, which occupies a lot of our time and a lot of our effort, is going to continue in the biological and behavioral sciences directorate. In fact, we are strengthening it there. We are strengthening it throughout the Government by essentially coordinating our effort and participating with other agencies that have a similar interest in this particular area.

I look at the Ethics and Values in Sciences Program as a very, very narrowly focused program, not as broad, or as encompassing as risk assessment and all of the things that are today high on our priority, that should be high on our priority, and are high on the priority of everyone.

Senator GORE. Well, you are right. Your answer did not satisfy me, and with the indulgence of the chairman, I would like to pursue it just a few short minutes further.

You referred to the Social Sciences Program as an alternative to it, but I hope you realize that it is completely different from this program that we are discussing here. It consists principally of data bases. It covers the whole gamut of economics and the others. It does fund a few grants in that area, but it is principally focused on other matters.

Now, this program did exist in isolation. It would exist in isolation wherever you put it, because it is kind of unique. It would always be isolated, because very few people stop to think about these kinds of things.

I would say, and I would argue as strongly as I possibly can, that we as a society must take the time to stop and consider these questions. And the NSF must stop and take the time to consider these questions.

You know, the whole American attitude toward science is in transition today. There was a time when we Americans looked at science as a savior and as a solver of all problems. I believe most people still largely look at it that way, but there has been a growing concern about the ability of science to push us headlong into areas where we don't want to go.

I think if you did a public opinion poll today and asked people whether or not the world would be better off if the atomic bomb had never been created, a lot of people might be surprised to see maybe 75 to 80 percent of the respondents saying yes, the world would be better off if that scientific discovery had never taken place.

Now, Americans see developments in genetic engineering and they see a lot of other developments that make them wonder whether or not some new Faustian bargains are about to be foisted upon us. And, as a result, the attitude toward science is threatening to change.

The response, the only intelligent response to that, is to accelerate the development of a new body of bioethics and ethics and values in science and technology to assure the American people that those who are pushing the frontiers of knowledge forward are doing so with an awareness of what the ethics and values involved are.

It is not as if we are talking about some kind of unsuccessful pork barrel program. We are talking about a very small program that has been very efficient and very successful in performing precisely the role which I just described. And at a time when these problems are becoming so much greater than they have ever been in the past, I think this program ought to be strengthened, and I am appalled at a recommendation to terminate it.

And I don't say that in a personal way. I understand the reasons as you have outlined them. I just happen to think that it is a mistake, and I hope to convince my colleagues on both sides of the aisle on this subcommittee that this small, tiny, worthy, valuable program ought to be continued.

Thank you, Mr. Chairman.

Senator GORTON. Thank you.

Mr. Bloch, we have kept you here for quite a while. Your testimony has been most interesting. I do have additional questions which I will submit to you in writing. We will also submit to you questions from Senator Riegle.

Senator GORTON. Thank you. And once again, welcome to your new position.

Senator GORE. Mr. Chairman, I would like to ask unanimous consent to include in the record letters from the University of Texas, from Harvard, from Vanderbilt, from Tufts, and a few others, and an article from the Chemical & Engineering News which is quite short, entitled "NSF's Plan To Eliminate Its Ethics and Science Program Opposed."

Senator GORTON. That will be included in the record, without objection.

Senator GORE. Thank you.

[The statement follows:]

STATEMENT OF ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and members of the subcommittee, it is a pleasure to be here this morning to talk about the National Science Foundation. My first six months as Director of the Foundation have been exciting, and I look forward to discussing our proposed programs for 1986 in this hearing.

The National Science Foundation meets its responsibility for the health of the scientific enterprise by supporting the most promising fundamental, long-term research by the best minds in all fields of science and engineering.

The principal products are: New knowledge and discoveries from the cutting edge of research; and the education and training of the world's most talented and creative scientists and engineers.

Gaining a new and deeper understanding of nature, and replenishing our supply of scientists and engineers are essential if we are to improve the Nation's industrial competitiveness, defense, economy, health and general well-being of our citizens.

In my discussion today I will focus on:

The challenges facing the scientific community, and the implications these have for the social and economic fabric of the U.S.

The Federal role, and in particular, the responsibilities of the National Science Foundation for scientific and engineering research.

The strategy the Foundation pursues to meet these reponsibilities, and carry out this Administration's strong policy for basic research.

Lastly, I will highlight the proposed budget for 1986, and discuss several activities in greater detail.

CHALLENGES FOR RESEARCH

As I see it, there are three major challengers facing us: the increasing complexity of scientific and engineering research; Resources needs and shortages; and World competition in key research areas.

Complexity and change are not new to science and engineering; but the complexity in research is greater and the rate of change is increasing in every aspect of science and engineering research compared to the past. We see this not only in the problems we have identified for study, but in the research process as well.

Analytical techniques and instrumentation are increasing in power, sophistication and cost. Yet, we must utilize these techniques if we are to explore, observe, and understand phenomena characterized by smaller scales, shorter times, and weaker signal strengths. Electron microscopes, radio telescopes and supercomputers have high price tags, but are absolutely essential if we are to continue to expand our base of scientific knowledge.

We are also beginning to experience breakdowns of the barriers between traditional disciplines and fields. We can see this clearly in such areas as biotechnology, materials science, engineering and computer science. At the interface of disciplines and fields is where major research progress often is made and new technologies emerge.

The complexity and increase in the rate of change demand constant communication, and a need to bring together scientists from traditionally distant disciplines to share and exchange knowledge, skills, resources, and equipment.

This changing environment will, if harnessed properly, have a positive effect on science and engineering knowledge and research: Basic research results will be shared, cross-stimulating and accelerating new research opportunities; and new institutional relationships will develop, fostering more cooperation—and participation—among industry, academia, and government.

The complexity of scientific and engineering research offers unlimited opportunities for expanding our knowledge and contributing ultimately to major improvements in our quality of life. The more we know, the more we want to know. And as we learn, we find more things we must learn about.

But, clearly, there are constraints, and one that we all face—as individuals and public officials—is resource availability.

This requires that we not only maintain a stimulating yet competitive environment for existing scientists and engineers, but also an environment that encourages our young students—the scientists and engineers of tomorrow—to seek careers in all fields of science and engineering.

Financial resources are also extremely important, especially with the need for costly instrumentation, equipment, and facilities necessary to carry out basic research. But they must be efficiently and effectively used; we cannot afford the luxury of "throwing dollars at research." On the other hand, we cannot bypass expensive research simply because it is expensive. What we must do is make choices, and we do this by assuring excellence, setting priorities, and focusing on important lines of inquiry.

The third challenge, world competition, comes in many forms. We, of course, are most familiar with economic competition. But there is competition in research also. This nation has always had a leadership role in technology, developed through the health and strength of our research base. This has enabled us to maintain and increase productivity.

But, there is an increased realization by industrialized nations that science and technology are at the heart of economic progress. As a result, we are beginning to see research efforts emphasized by foreign trading partners, challenging the U.S. leadership role in emerging fields such as supercomputers and biotechnology.

Emerging nations are emulating the success of industrialized nations by converting research results into marketable technology.

We must continue to be competitive by keeping our research and technology on the cutting edge, and by being first in translating research results into products in the marketplace. Clearly, we must work hard to maintain our preeminence in science and engineering research and technology; we cannot take it for granted.

The three challenges—complexity, resource availability and world competition—must be met successfully if we are to maintain a strong, growing industrial base for our nation, and continued improvements in the quality of life.

Today, there is resolve to meet these challenges head on. There is greater public awareness that basic scientific and engineering research is important to maintaining economic growth and improving the quality of life, and a more cooperative environment among industry, academia and government, ready to share in the responsibility to maintain scientific leadership.

2. ROLE OF GOVERNMENT AND THE NSF

If advancing science and technology is an important part of the answer, then we must ask: Whose responsibility is it to do the research? Train people? Provide funding?

Some years ago, the responsibiity might well have been placed squarely on the shoulders on the Federal Government. But there is a growing realization that many partners—including the Federal government, industry, state and local governments, and universities—have a stake in the outcome, and that each has a role to play and must be an active participant if we are to realize maximum benefits.

Let me briefly describe what part other major players have in scientific and engineering research.

Universities have a dual role: to educate and through research, contribute to the knowledge pool. These two roles are not separate. Research is an educational tool and it takes educated people to do research.

Industry has a stake in basic research because such research provides the basis for new developments and innovation, and, ultimately, new products and services.

State and local governments bear responsibility for education and economic development within their geographic regions. They must ensure that their education programs and facilities provide well-educated and trained graduates that will attract and promote economic development and expansion.

Let me now turn to the Federal role in supporting basic research. The Federal government provides about 67% of basic research support, research which ultimately benefits the entire nation in the long term across a broad and varied spectrum of products and services that maintain and improve the quality of life.

This national perspective allows us to:

Nurture promising new emerging science and engineering research without looking exclusively for immediate and high returns. Our payback will come in the knowledge that our investments in basic research today will improve life for our children and grandchildren.

Develop and maintain major basic research facilities that serve the complex, multidisciplinary requirements of today's research. Expensive equipment, accelerators, ships, telescopes, and supercomputers—must be shared if they are to be justified and properly utilized.

Draw on the best scientific and engineering talent available.

3. NSF GOALS AND STRATEGY

Now what about the goals and strategies of the National Science Foundation? What can we do to meet these challenges, and carry out this Administration's and the Congress' strong policy and funding support for basic scientific and engineering research?

The first goal is excellence. In science and engineering research, as in any creative endeavor, the best is vastly more valuable than the merely good.

Externally, in our grants and contracts for research, excellence means merit-based peer review. It is still the best way to ensure high quality and the best return for the nation's investment.

Internally, within the Foundation, we will concentrate on good management, using automation where possible to improve our efficiency.

Second, the Foundation must be a catalyst for change in the scientific and engineering community. This means not only pursuing new research opportunities, but also encouraging new ways to carry out such research.

Applying interdisciplinary approaches to new and emerging research possibilities.

Developing new relationships between government and private institutions, and between industry and universities.

Increasing communication, stimulating the sharing of expensive equipment, facilities, and knowledge.

While we may encourage science and engineering research to move in new directions in a concerted way, we must and will continue to support individual research projects carried out by a principal investigator and a few students. It is a simple yet most effective strategy.

The key is to balance this with large-scale cooperative efforts. There is ample opportunity and need for both: It is not a question of one approach or the other.

Third, NSF must try to improve the health of the science and engineering infrastructure. Instrumentation, special facilities integral to research and human resources must be the best if we are to revitalize the academic research base. We will continue to support new and enhanced instrumentation and access to it.

Fourth, we must continue to help attract, educate, and train students for science and engineering. We are doing this through:

Fellowships open to all qualified applicants; special programs directed at minorities, women, and the handicapped; programs designed to attract and retain faculty in disciplines where faculty shortages impede basic research progress; programs keyed to the improvement of precollege science and mathematics education; and increased support to undergraduate and graduate students through research projects.

Finally, we will continue to leverage government funds with private sector, state and local government, and academic support in all areas where cooperation is a possibility and in the best interests of all participants.

To move toward these goals given the budget environment for FY 1986, the Foundation made decisions to maximize the impact of funding available for academic scientific and engineering research activities, by:

Recognizing the need and the Administration's resolve to reduce administrative costs. We are holding down NSF's administrative costs which are already low compared to those of similar organizations.

Curtailing programs that are not in the mainstream of scientific and engineering research.

Stretching out construction and acquisition of several major research projects such as the VLBA.

Making trade-offs with ongoing base programs in order to provide for enhancements in several key areas where research is essential to the Nation's pursuit of scientific and technological excellence and to the training the next generation of scientists and engineers.

4. NSF BUDGET REQUEST

NSF's FY 1986 budget request continues the momentum established by this Administration, and supported by Congress, to keep U.S. scientific and engineering research at the leading edge.

The Foundation's FY 1986 Budget Request totals $1,569.4 million or 4.4% above the FY 1985 Current Plan of $,,502.7 million. It includes:

$1,397.8 million for Research and Related Activities, an increase of 7.4%.

$1,120.1 million for the U.S. Antarctic Program, up 8.4%.

$50.5 million of new obligational authority for Science and Engineering Education which, combined with a deferral of $31.5 million from FY 1985, provides total resources of $82.0 million, the same level as 1985.

This budget request, if approved by Congress:

Maintains support at current levels for research of proven quality across all disciplines.

Increases support for research related to U.S. economic competitiveness such as engineering research centers, and biotechnology.

Increases research programs that provide the basis for advances in science and technology, including the specific facilities that are an integral part of the proposed research. Some facility activities, however, while continuing to be funded will continue at a somewhat slower pace than originally planned.

Focuses presidential young investigator awards on faculty younger than previous recipients and provides an additional $6.0 million to support 100 new awards in 1986, bringing the total to 500.

These are some of the highlights of our 1986 request. There are several activities that I would like to discuss in greater detail.

SCIENCE AND ENGINEERING EDUCATION (SEE)

The FY 1986 program total for SEE is $82.0 million. This total includes an FY 1986 Request for new obligational authority of $50.5 million and deferral of $31.5 million from FY 1985. With the deferral, the FY 1986 Program total remains the same as the FY 1985 level.

DEFERRAL

Despite our initial optimism and best efforts there are several factors that make it unlikely that we will reach our earlier goal of full expenditure of all SEE funds (i.e., $113 million) in FY 1985, especially in the precollege programs. We will meet our previous goals in the Graduate Fellowships and College Science Instrumentation programs. However, we are encountering problems in the precollege area.

There are several reasons for this. First, funding levels in the precollege area have oscillated considerably over the past decade. In the 1976 to 1981 period, precollege funding was about $20 million per year; then it dropped to $3.4 million in FY 1982 and $1.1 million in FY 1983; and increased to about $68 million in available resources in FY 1984.

Neither the affected science and mathematics community nor NSF was ready for such an increase after FY 1982 and 1983. The result in FY 1984 was that we were able to spend $37.1 million, but had to carry over a $31.5 million balance into FY 1985. This carryover, plus the additional $49.7 million in newly appropriated funds for precollege activities, gave us a total of $82.0 million to obligate for those activities in FY 1985.

Gearing up to handle increases of this magnitude takes time, especially if we are to build a coherent program that addresses precollege science and math issues while maintaining our standard of excellence. The program also needs to provide a base for future years' activities.

Our staff and organization had to be completely rebuilt, and only recently have we come to adequate expertise and skill levels. We now have to begin building a comprehensive long range plan to deal with the issues related to science education and to make sure that the research efforts that the Foundation supports are coupled effectively to the over $144.5 billion investment being made in education by other Federal agencies, and by state, local, and private sources. Congress set aside in 1985 $2.0 million for this purpose, and we will go out this Spring with the first round of requests for planning proposals.

In science education, as in research endeavors generally, continuity and stability are critical for excellence. Even when funding is available to attract proposals, it takes time for good partnerships to form and become productive.

The quality of proposals we have seen so far is mixed. Part of this is due to the fact that the program is new, and the specific issues and objectives are just beginning to come into focus. We have seen and funded many excellent proposals, but in some cases even a collection of excellent proposals does not necessarily make a cohesive program—a program that is effectively coupled to the Nation's schools and teachers.

We expect this to change over the next year. As the program objectives become more clearly defined through the planning process more focussed proposals will be submitted and funded.

But at this point, we can prudently obligate only $50.5 million in the precollege programs in 1985. Thus, we are proposing the $31.5 million deferral as a planned carryover in 1986. We believe it is good management to carry forward funds that we will not be able to use effectively obligate in 1985.

THE EDUCATION FOR ECONOMIC SECURITY ACT (P.L. 98-377)

As you know, last year the Congress passed, and the President signed into law the Education for Economic Security Act, a bill to improve mathematics and science education in this country. NSF strongly supports the stated purpose and evident intent of the Act. Many of the programs authorized by that Act are very similar to the programs proposed by the President for FY 1985. As such, we are carrying those programs to the extent that our FY 1985 appropriations allow.

For FY 1986, the Foundation's budget request contains the Administration's proposed activities for NSF's science and engineering education program. This set of activities represents an appropriate set of activities for the Foundation in this area. We do not believe it necessary to seek reauthorization of those parts of the Education for Economic Security Act that reference the Foundation.

EDUCATION AND TRAINING

This country requires a constant supply of talented young students and graduates if we are to maintain our leadership role in scientific and engineering research.

NSF makes a significant contribution to ensure this supply of human resources. We have direct science and engineering education programs, and through research grants, provide opportunities for young scientists and engineers not only to enhance their education, but also to train with senior researchers and sophisticated instruments.

All education levels are addressed.

Our science and engineering (SEE) activity places speical emphasis on science and mathematics programs at the elementary and junior high school levels. At the same time, support will continue for promising programs at the high school level.

It is extremely important to nuture budding science interests in young students. One of the most successful educational shows sponsored by NSF for television is "3-2-1 Contact". This public television series about science, for 8 to 12 years olds, is broadcast daily on most of the 280 public TV stations, and is used in the morning by schools. It has won a number of awards, stimulated many science related activities across the U.S., and generated, without government funding, approximately 700,000 readers of "3-2-1 Contact" magazine.

At the undergraduate level, we support approximately 3,000 students participating in research grants, help with instructional equipment needs at the Nation's four-year colleges, and fund faculty research projects at predominantly undergraduate institutions.

The engineering research center initiative, for example, calls for the involvement of undergraduates in the program at all centers, thus giving future engineers early exposure to the research enterprise.

Support for graduate students and postdoctorals comes in large part from their participation in NSF-supported research grants. In 1986 the number of graduate students and postdocs supported on research grants is expected to increase 4%, to a total of 14,387.

The SEE activity also provides Graduate Research Fellowships, which will continue at the 1985 level of $27.3 million. In 1986, NSF will make 560 new awards, bringing the total number of graduate fellows supported up to approximately 1520.

Also, the Presidential Young Investigator Research Awards, initiated in FY 1984, will provide research support for the Nation's most promising young science and engineering faculty members. With matching funds and participation from the industrial sector, the awards are intended to encourage these young people to select and remain in academic careers, ensuring the excellence of the Nation's science and engineering education, training, and research.

BIOTECHNOLOGY

The United States is currently the world leader in most aspects of biotechnology. Maintaining that leadership through Federal, industrial and academic efforts, individually and in partnership, is important to the future of this country in economic growth, national security, quality of life, and scientific progress.

We cannot take that leadership role for granted; we must continue to work hard to maintain it.

While many Federal agenices—NIH, USDA, DOE, and DOD—support biotechnology research related to problem-oriented applications, NSF has a unique role to play.

We support a wide variety of basic research activities such as fundamental genetics, cell physiology, cell culture biology, nucleic acid chemistry and microbial ecology which are generally regarded as being essential to the further advancement of research in biotechnology. This research embraces fundamental scientific and engineering questions.

NSF is also the primary Federal supporter of basic research in systematics and ecology that form the scientific base necessary to assess the potential environmental impact of the various products and byproducts of biotechnology.

There are several areas where expanded NSF activity in FY 1986 could yield promising results. Enhanced support of knowledge-limited areas such as the chemistry of life processes, biochemical engineering, protoplast culture, and enzyme active site computer modeling. Increased support for training that bridges disciplines such as molecular biology and plant biology or ecology, chemistry and biochemistry; and chemical engineering and biology.

ENGINEERING RESEARCH

Engineering is the key to converting scientific progress and technological breakthroughs into useful products and processes. We recently restructured our engineering programs to focus on engineering research issues that are in part driven by technological needs as well as opportunities that are driven by new scientific discoveries.

This new thrust also recognizes the need for university and industry engineers to collaborate. The recently established Engineering Research Centers (ERCs) program will expand engineering research and is expected to facilitate cross-disciplinary research activities and to provide cross-disciplinary research experience for undergraduate and graduate students. The centers are expected to provide for exchanges between industry and faculty, and should develop fundamental knowledge across a broad spectrum of engineering that will enhance the international competitiveness of U.S. industry. The subject matter of the centers ranges from microelectronics and biotechnology, to manufacturing research. The latter, in particular, reflects renewed interest by universities in this economically important activity. After putting 142 proposals through the peer review process, the Board at tomorrow's meeting will act on the six centers that have been recommended for funding.

Industry participation is an important feature of the ERCs, as it is with the Industry/University Cooperative Research Centers (IUCs). NSF and industry share the cost of operating IUCs for five years, which the center is to be self-sustaining.

The IUCs are being managed in the Engineering Directorate because they are similar to the ERCs in that they are predominately engaged in engineering research. The IUCs, however, are much smaller in size and do not focus on that education needs of undergraduate and graduate students.

INTERNATIONAL

The Foundation's international research activities are becoming increasingly important to the overall success of our scientific and engineering research efforts.

Basic scientific and engineering research deals with fundamental questions of our universe, questions that transcend national boundaries. It is no small wonder, then, that international cooperation and communication are extremely important in advancing scientific and engineering research, and optimizing its results.

International participation provides access to special facilities, instruments and expertise located abroad; provides access to sites to observe natural and social phenomena; and encourages sharing the costs of large research installations. In addition, cooperative scientific and engineering programs often serve to support and strengthen U.S. foreign policy objectives.

One out of every five Foundation grants contains some form of international activity, ranging from travel for meetings held abroad to major global programs such as those in the atmospheric and ocean sciences.

The NSF has formal bilateral agreements for cooperative research with some 30 countries, cutting across a wide range of disciplines. We also provide support to the National Academy of Sciences for cooperation with sister academies in China and Eastern Europe, and participate in such Administration initiatives as the U.S.-India science and technology agreement.

For the most part, the discipline-oriented research directorates provide the major support and direction for international activities. There are two major international cooperative activities—Antarctic Research and Ocean Drilling—that together with some 700 other projects provide $73.0 million for research with international implications.

It is important for both scientific and engineering research and U.S. foreign policy objectives that these international research activities be continued.

COMPUTERS

The computer affects the research process in a fundamental way. Modeling and simulation complement experimentation and the insights gained are enhanced and compressed in time.

Computers and computer technology provide a unique challenge and opportunity to NSF-supported research activities.

As research tools, they provide incredible opportunities to explore, observe, and understand phenomena through which investigators are finding exciting new research questions to answer.

As research disciplines, computational mathematics, computer systems and design, information science, and other areas help advance the state-of-the-art in computer technology.

We are engaged in four activities to advance research on computers and research using computers.

Supercomputer facilities provide support for establishing and operating supercomputer centers, which will make available to the research community the most advanced computing equipment. Three temporary centers were established in 1984 to provide time on existing computers. In 1985 we will have three permanent facilities with class VII computers, a center using an experimental computer configuration, and a supercomputer transferred from the NASA inventory to the Foundation in last year's appropriation bill will be made available to university researchers.

Networking provides support for establishing access between science and engineering researchers and large-scale computing facilities. It also will provide advanced communiction services accessible to all members of the scientific community, which in turn promotes collaboration, resource sharing and rapid dissmination of research results.

Local Facilities assist in the acquisition and operation of essential computing facilities at the researcher's office or laboratory. This would include work stations, mini-computers, graphics facilities, local area networks, array processors, and other computing facilities or services needed on a daily basis to carry out research.

Research on Computers provides support for computational mathematics, computer design, information science, materials research, and other areas which help advance the state-of-the-art in computer technology.

The NSF has a unique—and quite essential—role because unlike other Federal agencies, it does not impose mission criteria in selection of the research projects. More importantly, NSF can provide support for computer research and computers across a wide spetrum of disciplines. Such support provides talent and knowledge that might not be otherwise available, especially in the training of graduate students in computer reserch and engineering.

INSTRUMENTATION

Earlier I discussed the need for new and improved instruments to keep our research efforts at the cutting edge.

During the last several years, we have placed strong emphasis on instrumentation, taking a flexible approach that is responsive to the needs of the researcher and the discipline. In fact, support for instrumentation has more than doubled since 1983 to $270 million in 1986. Included in this total is $121 million for capital equipment.

Equipment for all phases of research are supported: Individual research projects; multi-use special equipment programs and large centers and facilities; unique instruments and facilities; and college science instrumentation. The equipment may range from a small instrument used by a single researcher, to large capital items such as supercomputers, the Cornell Electron Storage Ring (CESR), the very long Baseline Array, and ocean-going ships accessible to large numbers of scientists and engineers.

CONTINENTAL LITHOSPHERE

The major focus of the Foundation's Earth Sciences subactivity in FY 1986 is the Continental Lithosphere, the relatively rigid exterior layer of the earth which moves in a series of plates over the earth's surface, forming the oceans, mountain ranges and configuration of the continents as we know them today. The continental crust, generated through eons of plate interactions, contains a partial record of deformation and volcanic events billions of years older than associated with oceanic lithosphere,

The Continental Lithosphere Program seeks to unravel this complex history. The program has drawn on reports of international bodies, the NAS/NRC and ad hoc panels incorporting several complementary appoaches:

Seismic reflection profiling that provides the highest resolution profiles of the lithosphere's upper 50 to 70 kilometers.

Seismograph arrays linked to computers that provide high-resolution imaging of crust and deeper parts of the lithosphere, and possible movements of the lithosphere and underlying mantle.

Geophysical sensing techniques that require calibration by drilling, for measurements that can be made in no other way.

Core sampling techniques for isotopic and other laboratory studies.

Satellite observations of crustal motions and support of laboratory studies to aid in interpretation of seismic data.

The aim of the Continental Lithosphere Program is an improved understanding of the earth's lithosphere in general, and of the crust underlying North America specifically, that could result in revolutionary scientific discoveries. These in turn could lead to breakthroughs in the search for possible future new energy sources and mineral deposits, responsible methods of waste disposal, and advances in prediction of earthquakes and volcanic activity.

Advances are also expected in the underwater exploration of the lithosphere; in particular, through the Ocean Drilling Program using the modern, newly-outfitted drillship JOIDES Resolution (Sedco/BP 471) that recently put to sea for scientific drilling.

POLAR PROGRAMS

For some time, the Foundation has been closely involved with the unique research opportunities available at the opposite ends of the world. Our focus on these regions continues as programs in the natural sciences respond to basic research questions.

Examples include investigation of the dynamics of the pack ice in the Arctic Ocean, terrestrial biology in the tundra of arctic Alaska, drilling of ice cores in Greenland for studies of climate trends, geophysical studies in the Svalbard group of islands, marine geology and oceanography in the far North Atlantic, and, currently, an assessment of the hugely productive ecosystem of the Bering Sea.

While the Foundation provides only 15 to 20 percent of the federal arctic research support, we have a new coordinating role as a result of the Arctic Research and Policy Act of 1984. The Foundation is responsible for the 11-member Interagency Arctic Research Policy Committee, and it provides assistance to the independent, Presidentially-appointed Arctic Research Commission. The new Act directs the development and implementation of national policies and research plans and more extensive coordination of federal agency planning and budgeting for arctic research.

In Antarctica, scientific research continues as the Nation's principal expression of policy and interest within that region, although in recent years, international political and diplomatic gestures have centered on management of the Antarctic, and particularly its natural resources.

In a recent international conference hosted by the National Academy of Sciences near the Beardmore Glacier, various groups from the Antarctic Treaty and other Nations had a frank exchange of views. The past successes of the Antarctic Treaty, and its ability to adapt to changing conditions and new member nations, were recognized clearly. We believe that the Antarctic Treaty should remain as the basis for any management regime for Antarctica.

Research in the last year included study of biotic production at and near the edge of antarctic sea ice, which occupies up to 7 percent of the world ocean. Biomass in this marginal ice zone has been found to be as dense as reported anywhere, and the studies from aboard an icebreaker, a research ship, and on the sea ice of McMurdo Sound are enabling investigators to understand and quantify this very important component of the Antarctic marine ecosystem.

In the coming 1985–1986 austral summer, approximately 100 research projects will be supported in astronomy, upper atmosphere physics, meteorology, glaciology, geology and geophysics, the ocean sciences, and biology.

We will reopen Siple Station, near the base of the Antarctic Penisula, for a final 2 years of operation in support of investigations of the ionosphere and the magentosphere.

Siple Station has been extremely productive scientifically, and the literature from this work is at the center of intellectual change in upper atmosphere physics. We will close the station in 1987 since it will have reached the end of its safe operating life.

Other improvements in antarctic operational support are the introduction of the ice-strengthened research ship *Polar Duke*, which has been chartered, the installation of satellite communications for data transfer from McMurdo, Palmer, and South Pole to the United States, and habitation improvements including a new water plant at McMurdo Station.

CONCLUSION

Mr. Chairman, this is a tough budget year for everybody. Hard decisions had to be made, and in this atmosphere it is sometimes difficult to focus on programs with long term paybacks; but that is our obligation.

The President had made his decisions, and the Foundation has fared well. That's important because this administration continues to believe, as I do, that basic scientific and engineering research is essential for continuing economic growth, maintaining the national security, and improving our quality of life.

We take this responsibility very seriously. We evaluated our programs and priorities and also had to make some hard decisions. We have forged this process into a 1986 request which maintains the momentum in new scientific and engineering research, builds a strong foundation for science and engineering education research, and achieves an optimal balance between investigator, group awards, and large facilities.

This budget request along with your continued support signals strong commitment to keep U.S. scientific and engineering research and technology the World's best.

I'll be happy to answer any questions you have.

(The following information was subsequently received for the record:)

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

ANTARCTIC TREATY CONFERENCE

Question. What was the purpose of the international conference on Antarctica in January of this year? What major Antarctic Treaty negotiations took place last year? What is planned for 1985?

Answer. The Antarctic Treaty Workshop at the Beardmore Glacier in Antarctica during January 1985 was patterned after a similar 1980 workshop at Chile's Teniente Marsh Base in the Antarctic Peninsula. The 1980 workshop was extremely effective in allowing a free and open exchange of views on the Antarctic minerals questions among knowledgeable experts in and out of government. There were two major factors in the success of that workshop: first, participants were invited as individuals, not as representatives of governments or other institutions, and were free to speak on substance rather than just express governmental positions; second, the venue was isolated from external distractions or interference, without media presence, and participants shared close quarters 24 hours a day under relatively spartan conditions. It was considered that the 1985 workshop would serve to accelerae resolution of the remaining issues of the minerals negotiations, and also promote understanding on the part of U.N. and third-world members by immersing them in the full panoply of considerations as well as in the real world environment of Antarctica.

Last year, the Antarctic Treaty Consultative Parties (ATCP) continued informal sessions fo the Special Consultative Meeting (SCM) negotiating an Antarctic Minerals Regime throughout 1984. Sessions were held in January in Washington, D.C., in September in Tokyo, Japan, and again in Washington in December 1984; the most recent formal session of this SCM was held in late Februrary 1985 in Rio de Janeiro, Brazil. These negotiations have made substantial progress toward a single negotiating text and there remain only a few difficult issues; however, final agreement is not anticipated for at least 2 more years. Also, a number of informal sessions were held among ATCP representatives in New York throughout the year to coordinate strategy and tactics in response to the U.N. Secretary General's Study on Antarctica, and for participation in discussions of this agenda item in the U.N. Genral Assembly in December. These efforts proved effective in forestalling an adverse resolution in the General Assembly, and the matter was referred to next years's General Assembly.

The XIIIth Antarctic Treaty Consultative Meeting (ATCM) is planned for late October 1985 in Brussels, Belgium. The agenda for this ATCM will be developed at a Preparatory Meeting of Delegations, also in Brussels, April 22-26, 1985.

Question. What aspects of the Foundation's biotechnology initiative will you emphasize in 1986?

Answer. Total NSF oligations for research related to biotechnolgoy in FY 1986 is projected to be between $75 million and $80 million. Within the broad area identified as biotechnology, the Foundation plans to concentrate on those research areas of a very fundamental and long-term nature. Examples of research topics in this category include the physical biochemistry and computer modeling of enzymes and membrance proteins, with the goal of determining precise structure-function relationships. These structural studies will allow the eventual directed modification of enzyme or protein active sites through genetic manipulation. Another high priority is the search for new mechanisms for the transfer of genetic material into all types of plant cells. The associated techniques of plant cell tissue culture and microinjection are also areas of special emphasis. The Foundation also intends to play an active role in the study of new techniques for scale-up technology in fermentation and product separation. An important portion of the biotechnology effort involves the multidisciplinary training of younger scientists through the award of postdoctoral fellowhisps in plant cell molecular biology; microbial ecology with an emphasis on molecular techniques; and the broader biological training of engineers.

Question. How will the Foundation coordinate biotechnology research within itself and between other Federal agencies?

Answer. Many of the most exciting research topics in the biological sciences funded by NSF involve plant cell biology. NSF has been a leader in the stimulation of a broad area of the molecular biology and gentics of plants and plant cells. This research program has been carefully coordinated with the U.S. Department of Agriculture (USDA). NSF and USDA have separate, but complementary research missions. The emphasis of USDA is to support basic and applied research related to food and agriculture whereas NSF supports the most fundamental research, some of which has significance to agricultural science.

USDA research is supported by three services within the USDA, which include the Agricultural Research Service (ARS), Cooperative States Research Service (CSRS) and Forest Service (FS). ARS supports work in the USDA system of national laboratories, and some NSF-supported scientists collaborate with these national laboratories.

CSRS provides formula funding for land grant institutions and runs the Competitive Research grants Office (CRGO). NSF staff and USDA staff in CSRS and CRGO routinely exchange information on supported proposals as well as proposals that are undergoing dual review. Generally, CSRS supports work of a more applied nature which does not overlap with NSF programs. Coordination with CRGO involves the active input of NSF through membership on the competitive Research Grants Office Policy Advisory Committee.

The FS supports primarily Federal scientists who work in National Forests. NSF-supported scientists have had excellent cooperation with the FS, especially in studies of long-term forest ecology.

Other coordination is conducted through the Interagency Committee Plant Sciences, which was organized by NSF and involves members from several agencies, including USDA. This committee meets 8–10 times a year to discuss scientific and policy issues. NSF is also represented on the Agrcultral Recombinant DNA Advisory Committee as well as the CROG Policy Advisory Committee.

Question. What will the effect of the cuts in the Office of Policy Research and Analysis? What will happen to research in risk analysis and technology assessment?

Answer. The effect of the budget cuts in Policy Research and Analysis (PRA) will be a curtailment of externally supported efforts and a greater focus on the performance of in-house analyses. Research in risk analysis and technology assessment will still be supported, although at a reduced level. Risk analysis, which was only one part of PRA, is also important to other programs within the Foundation. For example, biotechnology is playing an important role in the area of risk analysis because it is concerned with this issue in a very direct manner. What NSF can do, and do best, is provide the underpinnings for risk analysis, including the methodology, the tools, and generic solutions.

Question. The Committee is likely to restore the 5% pay cut proposed by the Administration. This comes to just $2 million for the Foundation. If we were to provide you with additional flexibility to improve the Program Development and Management (PD&M) Activity, how would you use these resources to improve oversight and accountability?

Answer. Once full restoration of the 5% pay cut is made, additional PD&M funds would be used mainly to increase travel, accelerate office automation, and improve the NSF Management Information System. Support for some of these items was decreased in FY 1985, due to the reductions imposed in Section 2901 of the Deficit Reduction Act. The funding enhancement, through increased support for these items, would provide for greater oversight of NSF-supported projects and improve overall accountability of NSF activities.

Question. You propose to reduce your administrative expenses by almost $1 million from last year's level. But the budget proposes a 7% increase in research activities. How can you expand research and at the same time reduce administrative expenses?

Answer. We plan to expand research and reduce administrative expenses by reallocating staff and by improving staff productivity through increased use of office automation. In the reallocation of staff, we have placed more people in the research directorates and reduced the number of people in other parts of the Foundation.

The Foundation has considered the problem of improving staff productivity for some time now and has identified a number of areas where realistic changes will produce significant improvements. Chief among these is providing employees with the appropriate work environment to do their jobs in the most effective manner. An example of this is providing employees with workstations having the specific data processing and communication links necessary to do a particular job.

As a result of wide availability of personal computers and staff trained in their use, a number of manual operations have been automated. For instance, input to the Foundation's annual budget submission to the Congress is now done almost entirely through the use of personal computers. As a result, significant manpower savings have been achieved.

Similar savings have resulted in using personal computers in the grants processing procedures, correspondence with grantees, and in other processes that are heavily labor intensive.

Question. Why does the number of grant awards proposed for FY 1986 decline when the research budget increases by 7 percent over FY 1985?

Answer. The number of awards projected for Research and Related Activities in FY 1986 is 10 (or less than 0.1%) below the 12,553 projected for FY 1985. Specifically, the FY 1986 NSF request includes support for 203 additional senior scientists and engineers, 117 additional postdoctoral researchers, and 441 additional graduate students. The FY 1986 request also includes a 13% increase for research instrumentation and facilities. These increases do not necessarily translate into additional awards, but rather into enhanced support for awards generally. Also, programs such as Advanced Scientific Computing and Engineering Research Centers receive substantial increases in FY 1986 request, but would make a small number of large awards.

Question. You undoubtedly have experience with instituting innovative approaches for information processing. Are you considering instituting any of these productivity improvement techniques at the Foundation?

Answer. Several different approaches are being pursued simultaneously; some are relatively advanced, others are in very early exploratory stages. NSF is accelerating its use of modern information handling technology to increase productivity, while simultaneously maintaining or improving work quality. At the present time, we are, for example, actively examining our information handling systems used in proposal and award processing and policy support.

Some specific illustrations might be of interest. On the hardware side, we are now evaluating vendors' proposals to supply us with several hundred microcomputers to be used in the daily work of the professional and support staffs. In addition, an experiment involving on-line proposal processing is in the planning stages. This is presently conceived as being a cooperative effort between investigators and the universities submitting the proposals, and peer reviewers in the academic community. We hope, by this means, to reduce the amount of paper generated and handled both inside and outside of NSF. In the shorter term, an in-house group, which is broadly representative of NSF activities, is implementing a series of recommendations to streamline current procedures by simplifying and automating data and proposal handling. Along an entirely different dimenson, we are developing a strategic plan for a decision support budget information system to be used in connection with policy development and implementation and budget planning, justification, preparation and execution.

Question. The Presidential Young Investigators program was designed to provide matching research support for our most promising young science and engineering faculty members. Thus far, about 60% of the awardees have obtained some degree of matching support. Do you see any ways in which industry participation might be improved in this program?

Answer. Recent data indicate that matching support has reached 68% of the programmatic maximum. The Foundation is continuing to expand its communications with industry, e.g., by sponsoring a second conference with key corporate officers this spring. We have been in close consultation with appropriate industry consortia and associations. This year for the first time a detailed brochure will be prepared containing the specific research interests of all new awardees.

Question. What is the status of the national supercomputer network that was discussed with this Committee last year?

Answer. The NSF Office of Advanced Scientific Computing is currently completing the development of a national scientific research network (SCIENCENET), which will consist of two phases. In Phase I, points of access will be added to existing networks (ARPANET, BITNET, CSNET, MAILNET, and MFENET) to provide NSF-supported researchers with access to supercomputer centers. In Phase II, several experiments to provide information required for developing SCIENCENET, will be tried. The experiments will include the establishment of one or more prototype high-bandwidth-based networks and the testing of the applicability of several communication protocols. We plan, with the phase II network, to serve the entire academic research community within the next three years.

Question. The Foundation has recently announced awards for 3 new supercomputer centers plus one experimental center. In addition, as a result of Congressional action, a supercomputer from NASA is to be transferred to NSF for installation at an academic institution. First, is the purpose of the transfer, e.g., to provide additional computing resources for academe, sound? Has it worked well? If other near state-of-the-art supercomputers become available from other Federal agencies, could NSF make effective use of them for basic academic research?

Answer. Yes, the purpose is sound. The NASA machine will be a welcome addition to the computing resources of the academic research community. The NSF Office of Advanced Scientific Computing is currently evaluating a proposal to transfer the NASA supercomputer to a university. If this evaluation is favorable, NSF will recommend that the machine be transferred this fall.

So far we have not identified, nor has any Federal agency indicated to us, any supercomputer that will not be fully utilized in the foreseeable future. Therefore, we do not see any such machines being available for transfer in the near future.

Question. Is the Very Long Baseline Array (VLBA) radio telescope still among the highest priority of the astronomy community?

Answer. Yes, the VLBA is unique in its productivity compared with the existing U.S. ad hoc very long baseline interferometry network and with all existing and planned systems elsewhere. It continues to have strong support from the astronomical community and remains as the highest priority major new program for ground-based astronomy. Our understanding of the universe will increase signficantly because of the VLBA.

Question. When do you expect to obligate the FY 1985 construction funds for the VLBA radio telescope?

Answer. At the request of the House Appropriations Committee, we now expect to begin to obligate the FY 1985 construction funds on May 15, 1985. The National Radio Astronomy Observatory (NRAO) is prepared to start construction at that time.

Question. The FY 1986, the budget request for this important telescope is $11.5M. Is this sufficient to keep the project on schedule?

Answer. Yes, the budget request of $11.5M for FY 1986 is sufficient to keep the project on the present 5-year schedule, while adhering to the terms of the negotiated fixed-price antenna subcontract.

However, it must be borne in mind that the optimum construction schedule, as originally presented by the National Radio Astronomy Observatory (NRAO), was a 3-year plan. In developing the FY 1985 request, a 4-year plan with approximately level funding of $15M (1985 $) was adopted. Congressional action delayed the start of construction to April 1, 1985, and reduced FY 1985 funding from the requested $15M to $9M. The budget request of $11.5M for FY 1986 stretches the construction funding period to 5 years, delaying completion by 2 years.

Question. Would you explain what you mean when you use the term "advanced materials," and where do you see the emerging research opportunities in this field?

Answer. Advanced materials are those that are specially tailored to have novel or improved properties by clever synthesis, characterization and processing. An example is multilayered materials, where individual layers are processed with precise control of chemical composition and dimension to create new classes of artificial materials with greatly improved properties (electronic, optical mechanical, high temperature stability, corrison-resistance, etc.), performance, and reliability. Other examples include the use of laser processing and ion implantation to modify the surface properties of materials in controlled ways for particular purposes, and hydrogenation of readily available amorphous silicon to produce inexpensive solar cells. The emerging opportunities lie in developing innovative synthesis, characterization and processing methods for future generations of materials, both crystalline and amorphous. These materials are sorely needed for electronic and structural applications, such as computer components and systems.

MATHEMATICS RESEARCH

Question. What has been NSF's response to the David Report concerning the state of fundamental research in mathematics?

Answer. The David Report recommended that Federal funding for the mathematical sciences be more than doubled within the next five years. Specifically, it recommended increases of 18% in constant dollars for each of five consecutive years. The proposed NSF increase of 15% for the mathematical sciences is a start in that direction, within the realities of the current budgetary situation. The increase will be used to provide additional support for graduate students and young investigators, and to provide funds for computational equipment and access to computational facilities. The requested increase for FY 1986 follows increases of 14.5% in FY 1985 and 18% in FY 1984.

In November 1984, the National Science Board passed a resolution concerning the David Report, which recommended that " . . . a concerted effort be made by all funding agencies to increase support for the mathematical sciences for several years until a proper level of sustaining support has been achieved."

EARTH SCIENCES BUDGET INCREASE

Question. Why has the budget increase in the Earth Sciences been limited to the Continental Lithosphere program and the Instrumentation and Facilities Program?

Answer. These two programs, Continental Lithosphere, and Instrumentation and Facilities, represent the highest priorities of the Earth Sciences subactivity. Both programs have broad support within the Foundation and the earth sciences community. The Continental Lithosphere Program actually consists of a number of programs and addresses problems in geophysics, geochemistry, and tectonics. These programs include Seismic Profiling, Seismograph Arrays, Continental Scientific Drilling and Satellite Geodesy. In FY 1985 new starts were made in all these areas. In FY 1986 funds will be used to:

continue the consortium on the Continental Reflection Profiling Project to provide new and existing discoveries about the deeper portions of the crust (a new regional consortium (CALCRUST) is providing detailed data on shallow crustal structure in Southern California);

continue design studies and begin construction of prototype seismograph array instrumentation;

continue site characterization studies of possible future drilling sites and permit limited testing of special core sampling techniques needed for deep scientific drilling; and begin to equip university researchers with receivers in order to allow them to use the NAVSTAR global positioning system for very precise geodetic observations of active tectonic processes.

The Instrumentation and Facilities Program addresses the need for large items of equipment and the support of large shared facilities. In the past years, the overall area of equipment has been poorly supported, and there has been a major decline in the quality and availability of research equipment. In addition, the field has yet to fully capitalize on recently developed instrumentation and the application of computer technology to data collection and analysis. The FY 1985 equipment proposals requested over $20,000,000, competing for the $5,000,000 allocated. The $1,200,000 increase is in partial response to this demand.

OCEAN DRILLING PROGRAM

Question. What is the status of the Ocean Drilling program including the indemnification authority that was provided to NSF by the Congress last year?

Answer. The Ocean Drilling program (ODP) is fully operational. The drilling vessel JOIDES RESOLUTION completed its shakedown cruise on January 29, 1985 and began operations on January 31, 1985. Leg 101 of the ODP was successfully completed on March 14 after drilling at 11 sites in the vicinity of the Bahamas. Shipboard scientists from Leg 101 report that the drilling vessel is excellent and the modifications made in the shipyard have made it highly efficient. Leg 102, dedicated to downhole measurements and experiments, left Miami on March 19 for site 418 in the Western Atlantic, south of Bermuda, and returned to Norfolk on April 11.

Ancillary shore-based activities are operational and a new facility is under construction. Engineering development and logistics and technical support units are in operation at Texas A&M University. The downhole logging group is based at Lamont-Doherty Geological Observatory (L-DGO). Core repositories are functioning at L-DGO and Scripps Institution of Oceanography. The State of Texas has begun construction of a 10,000 square foot building at Texas A&M University to house laboratories, offices, and a core repository.

Normal scientific planning is proceeding. Drilling targets are being developed in the following regions:

1985-86 North Atlantic Mediterranean and East Pacific
1986-87 (Austral summer) Weddell Sea
1987-88 Indian Ocean and Western Pacific

The status of international commitment is as follows:

France, The Federal Republic of Germany and Canada are full members of ODP. France and Germany have signed Memoranda of Understanding (MOU). Canada will sign on April 15, 1985.

Japan will become a full member on or before October 1, 1985, and has signed an MOU which confers observer status on Japan until it joins formally.

The United Kingdom and the European Science Foundation consortium consisting of Norway, Sweden, Denmark, Belgium, the Netherlands, Switzerland, Italy, Spain and Greece are considering the same arrangement as Japan.

The legal advice that the Foundation has received is that the indemnification authority included in last year's bill is valid only for the life of the appropriation for new obligations, i.e., 2 years. Indemnification in NSF's contract with Joint Oceanographic Institutions, Inc. is limited accordingly.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS THERETO

Question. The Engineering Research Centers program is of particular interest to this Committee and to me, and I commend NSF for undertaking this important initiative. What is the long-term goal of this program?

Answer. The goal of the Engineering Research Centers (ERC) program is to support centers to develop fundamental knowledge in engineering fields that will enhance the international competitiveness of U.S. industry and prepare engineers to contribute through better engineering practice. Engineering education and research are key elements in improving U.S. industrial productivity, and must be firmly linked in the centers. The centers will be supported to meet a need for providing cross-disciplinary research opportunities for faculty and students, for providing fundamental knowledge that can contribute to the solution of important national problems, and for preparing engineering graduates with the diversity and quality of education needed by U.S. industry.

Question. What are some of the particular technical areas in which you expect to fund centers?

Answer. The ERC program received 142 proposals from 106 different engineering schools, requesting approximately $2 billion over a 5-year period. Proposals were submitted in a wide range of topic areas. With the funds available, we were able to support six new centers. The centers and their areas of focus are listed below:

University of California, Santa Barbara: ERC for Robotic Systems in Microelectronics, Susan Hackwood, Center Director.

Columbia University: ERC for Telecommunications, Mischa Schwartz, Center Director.

University of Delaware: ERC for Composites Manufacturing Science and Engineering, Byron R. Pipes, Center Director. Rutgers University is also affiliated with this ERC.

University of Maryland: ERC for Systems Research, John S. Baras, Center Director. Harvard University is also affiliated with this ERC.

Massachusetts Institute of Technology: ERC for Biotechnology Process Engineering, Daniel I.C. Wang, Center Director.

Purdue University: ERC for Intelligent Manufacturing Systems, King-Sun Fu, Center Director.

The FY 1985 ERC Program Announcement provided examples of subject areas that influenced the topics of the proposals that were received. The FY 1986 Program Announcement states only that each center should focus on an area of technological concern, which is industrially and nationally important and where development of fundamental engineering knowledge will enhance international competitiveness.

It is planned that the FY 1987 Program Announcement will have a carefully selected list of suggested topics complementing those of the existing centers. The National Academy of Engineering will conduct a workshop this fall, after the FY 1986 proposals have been received, to assist NSF in determining the suggested list to be included in the FY 1987 announcement. The objective is to have a well balanced system of centers focused on nationally important topics, consistent with national technological problems and available resources.

Question. The Engineering Research Centers are an innovative experiment from which we hope to learn much about cross-disciplinary research and university-industry cooperation.

What steps will you take to evaluate these centers once they are in operation? What performance data will you collect? How will the organizational lessons learned from one center be made available to other centers?

Answer. The FY 1985 ERC Program Announcement states that three years after a center is established it will be evaluated by the ERC Panel (a high level panel established to advise the ERC program and assist in the review and evaluation process). The purpose of this evaluation is to determine if the center is meeting the goals and objectives proposed, including the quality of the research and educational activities and the extent of industrial participation. This evaluation will be used by NSF to determine whether to continue support or to provide decreased funding to terminate the center at the end of its five-year term.

From the beginning of the funding of the ERCs, NSF will periodically collect "indicators" of activity and progress for each center. These indicators are currently being developed in cooperation with the center directors.

Organizationan lessons learned from one center will be available to the other centers through several mechanisms. NSF is establishing liaison teams composed of NSF staff and consultants to monitor the progress of each center and offer guidance to help assure that each center is successful in meeting the ERC goals. In addition, all center directors will meet together as a group at least semi-annually to exchange information about managerial and other issues that affect the operation of the centers. Finally, we plan to establish a computer-based network to support the day-today interactions among the centers and with NSF.

Question. NSF's mission clearly is to support basic research, and that legitimately is your top concern. Yet your cooperative research programs indicate a willingness to support at least some industry-university research directed towards generic problems in such areas as robotics.

If industry and the Congress were to determine that more, not fewer, government-industry-university partnerships in generic technology are needed to help this nation regain industrial competitiveness, which agency do you believe should be given this additional responsibility? Should it go to NSF? If so, would it compromise the Foundation's basic research mission?

Answer. The research support provided by NSF's engineering programs contributes a generic base of fundamental knowledge that underlies the development of new technologies. Some examples of new technologies are robotics, automated manufacturing, and biotechnology. NSF has not supported the actual developmentf of these technologies, but has left that role to industry. In recent years, NSF has encouraged industrial partnerships to explore generic fundamental and applied research topics that underlie technological advancement. This support has been provided through the Industry/University Cooperative Research Projects and Centers programs and through the recently established Engineering Research Centers program.

The Engineering Directorate has recently reorganized and, as part of this reorganization, has established two new divisions for Science Base Development in Design, Manufacturing and Computer Engineering and for Fundamental Research in Emerging and Critical Engineering Systems. These divisions focus on providing the knowledge base and personnel needed to advance research in such critical technological areas as automation, robotics, biotechnology, and lightwave technology. Although these divisions do not operate in the formal industry/university cooperative mode, they actively involve industry in the planning, review, and evaluation of their programs and projects.

We believe that the reorientation of the Engineering Directorate toward providing both a base of support for the engineering sciences and for fields of engineering that more directly underpin technological advancement is a significantly new focus for NSF. With this new focus, NSF could assume additional responsibilities for government-university-industry research partnerships in generic technology without compromising its basic research mission.

Question. The Senate Budget Committee has approved a freeze of the government's general science and technology expenditures. In time, that principle may be extended to a freeze of NSF's budget.

What impact would a FY 1986 budget freeze at FY 1985 levels have on the Foundation and especially its research programs? What would you cut? Please provide specific details.

Answer. A budget freeze at the FY 1985 level would have serious consequences for NSF. It would involve about a $67 million reduction from our FY 1986 program plan and would have ramifications across most of the Foundation's programs.

If faced with such a freeze situation, the general strategy would be to protect scientists (people) support to the maximum extent possible and to seek reductions in instrumentation and facilities first. This would mean, for example, that our large capital improvement projects such as the Cornell Electron Storage Ring (CESR), the Wisconsin Synchrotron (Aladdin), and the Very Long Baseline Array (VLBA) would have to be examined for further stretchout or deferral. Instrumentation increases would need to be reduced across the full range of scientific disciplines, which would slow the gains we have been making in this area over the last three years.

Our program of Engineering Research Centers would probably need to be reduced, which would result in fewer new centers in FY 1986, and in addition, the build-up rate of the FY 1985 centers would have to be slowed. A similar determination would have to be made with regard to the supercomputer initiative. No new centers could be considered in FY 1986. In project support, increments to several important initiatives would have to be reduced by about 50%, e.g., in advanced materials, biotechnology, continental lithosphere, mathematics personnel, and social and economic sciences. In the Antarctic program, plans for renovation and replacement of buildings would also be candidates for reduction.

Reductions on this scale would seriously slow the momentum that has been built up in previous years in areas important to scientific progress and economic security. If we do not invest in graduate students, post-doctorates, and faculty researchers today, the talent and ideas needed for the future will not be available when the Nation needs them.

Question. Some of the senior staff positions at the Foundation that require Presidential appointment have been vacant for over two years. At the hearing you discussed your views on the subject. Would you please elaborate further. Have these vacancies hampered administration of the Foundation? Is it necessary for Assistant Directors to be Presidentially appointed?

Answer. The Foundation's senior staff positions include, among others, four Presidentially appointed Assistant Directors (AD's). Currently, two of these positions are filled while two are vacant. The filled positions are those for the Assistant Director for Biological, Behavioral, and Social Sciences, and the Assistant Director for Engineering. The vacant positions are those for the Assistant Director for Mathematical and Physical Sciences and the Assistant Director Astronomical, Atmospheric, Earth, and Ocean Sciences. These positions have remained vacant for about two years, and the senior administrative duties in these directorates have been performed by staff members serving in an acting capacity.

The Assistant Directors are key to the administration of the Foundation. They control what happens on a day-to-day basis and make the decisions in their respective directorates. It is essential that a complete team be put in place to ensure the most effective management of the Foundation.

However, I do not believe that the Assistant Directors need to be Presidentially appointed. The Foundation should have the authority to fill these positions as rapidly as possible, and I urge Congress to examine this particular area for possible revisions to existing legislation concerning appointment of NSF Assistant Directors.

Senator GORTON. Dr. Press, we are delighted to have you back again, and we welcome your testimony.

STATEMENT OF DR. FRANK PRESS, PRESIDENT, NATIONAL ACADEMY OF SCIENCES

Dr. PRESS. Mr. Chairman, how much time do you have? Do you have to run off? Shall I cut my testimony?

Senator GORTON. We have effectively decided not to run off. So you give us your statement. That is more important than the alternatives.

Dr. PRESS. Thank you.

May I start by telling you I spent a wonderful week as a visiting professor at the University of Washington and was very much impressed with the student body, the faculty, their enthusiasm, their quality.

Senator GORTON. Thank you.

Dr. PRESS. Well, I am pleased to join you this morning to discuss the fiscal 1986 budget proposed by the National Science Foundation, and I would like to split my testimony into four parts: The context for the budget; the current dynamics of science and technology and how well the budget responds to them; some impressive aspects of the proposed budget; and some specific concerns.

First, the context of the budget. It is quite familiar to the chairman and the subcommittee that the national deficit is now the ghost as the banquet in the budget process, and however painful it is, all of us must be realistic about what is achievable.

Further, no matter how fervently we believe in the value of science and its technological handmaiden—technology—to the country, the scientific community must not open itself to the all-too-easy charge of special pleading. Rather, we must continue to make a convincing case that the support of science and engineering research is a profitable investment, the most profitable one that the United States can make in its future, and then let the political process establish the budgetary priorities.

That said, the context still remains one of a basically inelastic budget and it is a context that is quite likely to endure for the next several fiscal years. Thus, the prudent planning course for the NSF is to anticipate not just one bout of austerity, but rather several such bouts. And the Foundation has done precisely that with its 1986 budget.

Thus, the Foundation's budget reflects deliberate choices to emphasize programs that it strongly believes must be sustained and to trim or eliminate others that, while worthy, are less important or less realizable. It continues to strengthen the heart of the Foundation's programs and indeed the heart of the Foundation's reason for being—to support basic research in the United States.

For example, in its proposed budget, the Foundation has strengthened its support for the physical and mathematical sciences, and with vigor and imagination it has reinvigorated its efforts in engineering research. It has made its priorities clear.

Thus, while the overall budget increase is about 5 percent, the increases in the research directorates range from 6 to 13 percent.

Further, the Foundation's budget reflects as strong as a commitment as any Federal agency can reasonably make to widening access to the research community of what is now the single most powerful instrument of science and technology—the advanced computer.

It also offers realistic approaches to supporting improvements in vital scientific facilites, including the very long baseline array telescope and the Cornell electron storage ring.

Finally, the Foundation's budget responds to current realities through its determination to leverage the Nation's investments effectively, and many examples could be cited. Two prominent ones are the Foundation's support for engineering research centers, which you heard so much about this morning, and the Presidential Young Investigators Programs. Both programs are premised upon industrial involvement and commitment. That premise is correct financially in expanding the impact of Federal dollars, and it is correct intellectually.

These programs will enrich the Nation's cadre of first-rate researchers, and they will enrich the Nation's capacity to translate their work into economic and social benefits.

To move to my second point, the Foundation's proposed budget fits not only the Federal context, but also that of the current dynamics of science and technology, and these dynamics are shaped by interlocking elements. They include the quite incredible pace and diversity of discoveries in science and technology.

Recombinant DNA technology was a mysterious, cryptic, even frightening phrase 10 years ago. It now drives an expanding industry; 8 years ago, monoclonal antibodies were dreamt of. Now, they have won Nobels for their discoverers, have sparked a new industry, and are transforming the diagnosis and treatment of dread diseases, including cancer; 4 years ago, we were unaware of what may be the largest coherent structures in the universe: jets of gas streaming out quasars and galaxies some hundreds to thousands of light years in length. Now, these jets have been modeled on supercomputers, their structures deciphered, and some ideas about their origins supported.

These dynamics of discovery are, of course, joined by others. They include the increasing cross-disciplinary character of scientific work. To illustrate, the recent and very important advances in surface science underlying a new generation of semiconductors grew out of the collaboration of chemists, physicists, materials researchers, and engineers. And, of course, the vigorous efforts of other nations to strengthen their capacities in science and technology sharpen another dynamic of current science policy: the urgent necessity to translate rapidly new knowledge into general utility.

In sum, the foundation's budget responds extremely well to this context, that of the current ecology of science and technology. It does this by its emphasis on fundamental research. It does it by strengthening its programs in biotechnology, especially in building bridges among the relative disciplines.

More subtly, it does it by implicitly making multiyear commitments for several of its programs; notably, the Engineering Research Centers and the new Centers for Advanced Computers.

While single year funding remains a reasonable instrument, the fact is that in the light of the rapid pace of discovery and application, the programs escalate when each year researchers must renew in full detail their requests for continuing support.

Overall, then, the foundation's budget is impressive in responding to the pincing pressures of Federal deficit and to the white heat pace of scientific and engineering research both in the United States and in a list of other countries.

The third part of my discussion of the NSF budget, that is, especially salutory aspects, has been dealt with mostly. However, I do want to note this budget's clear articulation of priorities. It reflects the director's emphasis on people first, then instrumentation, and finally facilities. It reflects a determination to maximize the impact of available dollars. It reflects well-reasoned choices. It reflects a willingness to cut programs in every directorate.

A recurring bromide when Erich Bloch came to Washington was that academic science would be slighted by virtue of his background in industry and engineering. I think this budget should inter that particular worry. In fact, the director has, in the context of these times, produced a highly defensible budget, and I urge the subcommittee to support it.

As I said at the outset, the fourth part of my discussion of the NSF budget for fiscal year 1986 goes to some specific concerns which the subcommittee might ponder. The first deals with the heart of the NSF program: core support or, more formally, basic science research project support. The second deals with the NSF role in education.

Regarding support, much of the growth in research funding has occurred in programs committed to specific purposes. Thus, the bulk of the growth and research obligations between 1982 and 1986 has been in programs such as the Engineering Research Centers, Advanced Scientific Computing, Presidential Young Investigators, and Instrumentation; that is, for specific categories of research support.

The pool of money available for general research support has grown relatively little; in fact, from $736 million in 1982 to $870 million now. And in terms of fiscal year 1986 dollars, it shows a slight decline, from $951 million in 1985 to $932 million in the proposed budget.

I offer these comments not as criticisms, but as matters for the subcommittee to ponder. Committing incremental increases in research support to programs such as the Engineering Research Centers reflect deliberate policy and important goals.

Further, while core research support has declined in constant dollars, support for instrumentation research has grown substantially between 1982 and 1986.

The question really goes to the importance of a static pool of unencumbered general research support on the overall health of science and technology, and it goes to NSF's vital role in supporting the individual researchers.

I emphasize again that I support fully the Engineering Research Centers, Advanced Computing, and the like. The real issue is more of a philosophical one: whether the growth in core support is adequate or whether we should emphasize these special programs.

My second concern which I would like to share with the subcommittee deals with the NSF program in science and engineering education. This subcommittee knows well the roller-coaster history of recent NSF education budgets. The NSF budget for precollege education virtually disappeared in 1982. With the fiscal year 1986 proposals, the education budget has returned to slightly above what it was in 1979.

Against that tortuous history, the progress made by NSF in returning to precollege education is commendable. Understandably, all of us would like to see more done faster, but we should not let frustration cloud both our perceptions of the progress that has been made and our support for the wise and courageous decision by the Director to defer a portion of the fiscal 1985 funds into the next fiscal year.

First, the Director should be supported in his judgment that, for the current fiscal year, the mix of programs and proposals received does not justify the intended level of spending.

Second, we should remember that without the deferral, we risk again the precipitous change in budget levels from about $113 million in 1985 to about $51 million in 1986.

A final point is that the NSF education budget is microscopic compared to the size of the U.S. education enterprise. It is a few tenths of 1 percent. If the NSF education programs are to be truly effective, if that really relatively small investment is to be well-leveraged, then these programs must be soundly constructed. There is considerable merit to the criticisms made of past programs and pre-college science education. There were often uncoordinated, consisted in the main of a collection of small programs, and lacked leveraging power.

The Director must be given both discretion and time if that experience is not to be repeated.

Summarizing, I believe that this budget reflects a well-reasoned plan to leverage effectively the Federal investment in basic research. It is reasonable in tempering itself to current realities; notably, the budget deficit. And it is wise both in planning for continuing austerity and in emphasizing programs basic to enhancing the Nation's strength in fundamental research.

Thank you, Mr. Chairman.

Senator GORTON. Frank, I know the Foundation and its Director appreciate, as I do, that thoughtful and generous analysis.

I start you with the same question I started the two earlier witnesses with; that is, that if the recommendation of the Senate Budget Committee turns to reality, we will be looking at the grim task of reducing this overall proposal by $50 or $60 million.

If it must do that, how should NSF go about setting those new and more difficult priorities?

Dr. PRESS. I opened my testimony expressing the difficuly that you will be facing in making some of these very tough decisions in the face of this huge budget deficit, and it is very hard to compare or justify science programs when social programs are being cut and so on.

The best that I can do for you, again, is to make the case for science and to make the point that more than ever before, the economic viability of this Nation, the creation of new jobs, our ability to become low-cost, high-quality producers so that we compete in the world, depends on the rapid pace of science and the introduction of the new technologies based upon science into our economy.

I think that is the wave of the future. Japan has recognized that. And I hate to be the 1,000th voice that has been here to tell you that the future of the Nation and its national defense depends on the support of science. But I really do believe that these investments in scientists, in engineers, in new discoveries which are advancing at a mind-boggling pace, in the shortening of time between a scientific discovery and commercialization and the creation of new industry, these are phenomena that are new, that have never happened before. And therefore, I would urge you to seriously consider this investment in science as represented by this budget.

And that is why I do support this budget.

Senator GORTON. Thank you, Doctor, You are, unfortunately, carrying coals to Newcastle with the only member here at this point. We didn't get very many votes in the initial stages of this debate, but we will keep on trying.

Last year, you were critical of the engineering amendments which are now part of the administration's draft bill. Do you retain that criticism or have you come to terms with it?

Dr. PRESS. I was rather a voice in the wilderness last year. I didn't get much support either from the scientific community or in Congress.

I would like to make the point, however, that the engineering schools have been in serious trouble and they still are. The only way we will become these low-cost producers that I think we have to be to compete, high-quality, low-cost, and to partake in this game in the years ahead is to turn out a higher quality of engineer, and our engineering schools have to improve in order to do that, and to make sure that they go into the economy well-trained.

I would have preferred an across-the-board governmental effort to improve our engineering schools, involving all of the department of government. More funds go into engineering research from other departments in aggregate than from the National Science Foundation. And I was concerned that all of the needs of the engineering schools—and they are real and they are significant—be loaded on the National Science Foundation.

The Foundation was established with a mission and, more than any other agency, I believe, it has honored that mission well—the support of science in the United States. And I thought it would be rather opening a Pandora's box of loading additional missions on the National Science Foundation—first engineering, then social science, then this area and that area—rather than solving these problems in a way that are more natural, involving the whole of the Government.

I am not terribly concerned that these amendments will harm the National Science Foundation, and so I am not going to be a vigorous advocate against them.

Senator GORTON. In comments which have been submitted to us for the record, the American Chemical Society urges the Foundation to strengthen the interactions of the Interagency Working Group on Research Instrumentation so that its money is spent more wisely.

I would appreciate your comments, more broadly than that, on efforts to improve instruments in general.

Dr. PRESS. Dr. Bloch's testimony involving the national need for instrumentation, the budgetary levels that are required to provide our scientists with state-of-the-art instrumentation, I think, describes the case accurately.

We have a very strong scientific community. The pace of their discoveries, as I said before, is really mind-boggling. Their limitations at the present time are mostly access to adequate instrumentation and facilities. And if you accept my argument, as you graciously said you do, of the importance of science to the future of the country and all of its dimensions, then we should do more for instrumentation. And again, we can't load it entirely on the National Science Foundation.

And so I support the efforts across the Government involving the Department of Energy, NASA, the Defense Department, the National Science Foundation, the NIH, to look at this as a national need requiring a coordinated across-the-government program to address it adequately.

So I agree with the thrust of the American Chemical Society's presentation to you.

Senator GORTON. We have received some criticism that the Presidential Young Investigators Program will lead to a concentration of grants in a handful of the most prestigious universities in the United States because they are individual and portable.

Is that valid or invalid criticism? Should some money go to institutions on a competitive basis, as opposed to individuals?

Dr. PRESS. I haven't looked at the demographics of where the Presidential Investigators or, for that matter, the National Science Foundation's Fellows go, for a number of years. The last time I looked at it, I thought there was a correlation, not between elitist places and nonelitist places, but between population centers; that it was rather distributed according to the numbers of people residing in each part of the country.

If there is a distortion, that might have to be addressed. On a number of occasions, I have thought that—and I have suggested—that we might have in this country a two-tier system in the distribution of science support funds, both education training and research. One you might call a national competition where the best proposals and the best projects get supported, and one—speaking realistically and pragmatically—based upon the best proposals within a region, or perhaps even within a State.

More and more, States are beginning to recognize that their own futures at their own local level depend upon the quality of their universities, the quality of the research programs in their universities, the quality of their educational establishment. And I think we have to recognize that in the manner that I have just described.

Senator GORTON. Finally, do you wish to enter the debate between the director and Senator Gore?

Dr. PRESS. I don't think I can stay out of it. Let me say this. There is no question in my mind about the value of having multidimensioned individuals, thoughtful individuals, addressing these difficult questions of ethics and values in science.

My own academy's program in this area is expanding very rapidly, and I suspect in the years ahead may be the most significant growth area. We invited Senator Gore to give a keynote address a few weeks at the academy in a symposium dealing with these matters.

So although I agree with him about the importance of this area, I myself have not evaluated the specific program within the National Science Foundation. And so I cannot make a specific recommendation with respect to the EVIST Program. But were I the director of the Foundation, I think I would have done the following: I would have transferred the program into the Social Science Directorate formally, where the philosophy of science, the history of science also resides, where legal aspects of science and technology—there are all sorts of programs there.

But I would have also instructed that directorate as follows: I want this program to grow, as long as the quality and the impact can justify it, because there is no question about the importance to the country. And then I would have had that directorate bring in the best outside advisors and evaluators from all walks of life—religious, legal, former Government officials, scientists, engineers, industrial people, and have them evaluate and discuss these programs, and make recommendations about how rapidly such a program should grow.

Senator GORTON. Thank you very much, Doctor. I greatly appreciate your advice.

We are adjourned.

[Whereupon, at 11:16 o'clock a.m., the hearing in the above-entitled matter was adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF DR. ROLAND W. SCHMITT, CHAIRMAN, NATIONAL SCIENCE BOARD

Mr. Chairman and Members of the Subcommittee,

I am sorry not to be able to be present at your hearing on the National Science Foundation's authorization of the FY 1986 budget and would like to present a statement for the record. I will summarize some of the science and engineering policy issues that bear on the strategy behind this budget, and some of the priorities it addresses.

Today the Nation faces heightened international competitive challenges—economic, military, and technological. This competition broadens demands on science and engineering research and education. These pressures make it more important than ever before to strengthen the science and engineering base that underlies all our technology efforts. That base determines the ability to perform forefront research, and to renew the Nation's supply of first-rate scientists and engineers. But at the very time demands are greatest, we face the prospect of deteriorating research and education capabilities in our great universities, due to shortages of faculty and of up-to-date equipment for instruction and research.

The Federal Government plays the leading role in supporting universities in their efforts to do research and provide personnel for the future. So, even in a time of necessarily constrained budgets and hard choices among many worthwhile goals, the President's FY 1986 budget attaches priority to the continuing need for strengthening the academic science and engineering base on which the Nation's economic and military security depend.

This need is being met by several recent initiatives that provide new environments and capabilities for strengthening research and education. The National Science Foundation has begun the process of creating Engineering Research Centers—a new form of university-industry cooperative research effort that puts cross-disciplinary teams of engineering faculty and undergraduate and graduate students to work on problems that combine intellectual excitement with economic value. The concept has received strong support from the President's Science Advisor, the National Science Broad, the National Academy of Engineering, and industry. I urge your continued support of this new concept for gaining fundamental engineering knowledge while educating future engineers.

Another such initiative is the plan to establish advanced scientific computing centers, to enhance progress in many areas of science and engineering research and education. The computing revolution has created dramatic improvements in all aspects of doing science and technology, from experimentation to computer modeling to computer-aided design and engineering. Strengthening the science and engineering base requires making sure the next generation of scientists and engineers can use these tools. The proposed centers were judged in part on their close involvement with high quality research projects and their educational value in teaching students and researchers to use the most advanced computers. The National Science Board last month approved the initiation of four centers.

Universities continue to experience severe problems in obtaining state-of-the-art research instrumentation. In response the NSF is continuing to increase support for instrumentation on all levels, from individual projects and investigators to national centers serving hundreds of scientists and engineers. First-rate instrumentation is essential, both for research and for the education of tomorrow's innovators and investigators.

Another major initiative, the Presidential Young Investigators Program, addresses the problem of faculty shortages. Universities need outstanding scientists and engineers in teaching positions if they hope to turn our outstanding graduates in science and engineering. But retaining those teachers is difficult, given the high demand for their skills in non-teaching jobs. The Presidential Young Investigators Program provides a big incentive for staying in teaching—NSF research funding and matching industrial support up to total of $100,000 a year for five years. The

Nation's engineering and science communities and its advanced-technology industries strongly support this program, and I urge your continued support for it.

Science and engineering education also needs strengthening, particularly at the precollege levels. As many of you know, this need has been voiced in many recent reports. The NSF is responding with new efforts to strengthen its science and engineering education programs. The National Science Board strongly supports those efforts.

And, finally, the past decade has witnessed a phenomenal expansion in biological science and technology. Continued American leadership here will depend on the strength of the science and engineering base. In response, the NSF is undertaking an initiative that will support biotechnology-related research underlying such goals as the improved growth and utilization of food and fiber crops, better medicines and diagnostic techniques, and improved production of specialty chemicals. The initiative will also support the education of the bio-engineers needed to assist the turning of basic knowledge into practical processes and products.

These are some of the initiatives meeting what I regard as the NSF's top priority—strenghtening the Nation's science and engineering base. I'll conclude by describing how we have restructured the National Science Board to increase its involvement in developing NSF policy, and in national science policy in general.

To help the Foundation respond to human resource needs more effectively, we have established a Committee on Education and Human Resources to oversee the Foundation's efforts in science and engineering education. It will also address science and engineering personnel issues, including efforts to bring minorities, women, and the handicapped into science and engineering careers.

To oversee NSF long-range planning and program implementation more effectively, we have established a Committee on Programs and Plans. We want to move away from reliance on approval of awards as the primary mechanism for NSB oversight of NSF programs. As you know, the NSF Act requires that the Board approve awards above amounts fixed in the statute. We are seeking your support of an amendment to the NSF Act that would eliminate any specification in law of an amount above which the Board could not delegate approval authority to the Director. We believe that by reducing the number of individual grants we are required to review based solely on the dollar limit, we can spend more of our time reviewing programs with special policy significance, such as the initiatives I noted previously. And we will be able to get involved earlier in the decisionmaking process.

We have worked very closely with Erich Bloch in devising the recent changes in the Board's structure, with the aim of involving the Board more fully in the substance of the Nation's science and engineering policy level problems, opportunities, and issues. The National Science Board can only be as effective and useful as the Director wants it to be. This Director has made it very clear that he wants an active, strong Board. It is a pleasure to work with him.

Finally, let me give you some examples of the tasks the Board will take on during 1985. At the broadest level, we will work with the Director to develop NSF's goals, organizational, philosophy, and future program directions. We will also examine changes in the institutional framework for supporting university-based science and engineering, NSF's role in fundamental computational science in relation to other agencies, and the development of the initiatives I just reviewed—science and engineering education, engineering research centers, advanced scientific computing, and so on. We will also continue our reviews of science in the international setting, and of research excellence and the breadth of research participation. The question of how we can foster and maintain excellence in our reseach universities in the context of national needs and priorities is one that we must all address.

The Board looks forward to working with Erich Bloch as he tackles these tasks and implements the strategic directions for the National Science Foundation that you have supported in recent years.

STATEMENT OF DR. ROBERT M. WHITE,[1] PRESIDENT, NATIONAL ACADEMY OF ENGINEERING

I welcome this opportunity to submit a statement on the Fiscal Year 1986 budget proposal of the National Science Foundation (NSF). I will comment principally on the engineering aspects of the NSF Fiscal Year 1986 budget.

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[1] These remarks are made in Dr. White's personal capacity and do not represent the views of the National Academy of Engineering (NAE).

Our nation faces an unprecedented challenge to its technological leadership and industrial competitiveness. It is important therefore that the NSF proposals be viewed not only through the prism of science and the contribution that the effort can make to the improvcd understanding of natural processes, but also through the prism of engineering and technology and the contribution they can make to our industrial competitiveness.

The reason that this is a vital dimension in our consideration of the NSF budget is evidenced by the attention that has been called to this issue in the President's State of the Union Message; the issuance of the report of the President's Commission on Industrial Competitiveness entitled "Global Competition: The New Reality." Only several weeks ago, as if to mark the importance of engineering and technology in our national life, the President awarded the first National Technology Medals. The National Academy of Engineering has adopted as the major theme for its work over the next decade—the advancement of the nation's industrial competitiveness and its technological leadership.

While we all recognize that the advancement of this country's industrial competitiveness depends on many factors extending far beyond the realms of science and engineering, embracing fundamental questions of national economic policy, it is nevertheless generally recognized that at the core lies the national ability to be preeminent in science and engineering. The mission of the National Science Foundation to support basic scientific and engineering research and education in our universities therefore makes its programs central to the long-term industrial competitiveness of this nation, because our technological edge depends upon the availability of the highest quality scientific and engineering talent.

It is in this light that I urge the support of the President's fiscal year 1986 budget. The National Science Foundation seeks an increase over its fiscal year 1985 budget of approximately $100 million, about six percent. This is a modest overall increase, and one that in my view is essential to the vigor of the scientific and engineering enterprise in the university community in this country.

The proposed budget for engineering represents an increase from fiscal year 1985 to fiscal year 1986 of 13 percent from $150 million to $170 million. This is the largest increase for any of the activities of the National Science Foundation. It is a most welcome action. It continues the strengthening of the engineering activities of the NSF begun some two years ago and represents a recognition of the growing importance of engineering research and education in maintaining the technological leadership of the nation. I should indicate, however, that the total funding for engineering within the National Science Foundation remains just a small fraction of its total effort and has increased from only 10 percent of the total NSF activities in fiscal year 1985 to 10.6 percnet in fiscal year 1986.

The increasing recognition by its leadership of the importance of engineering in the National Science Foundation has been accompanied by fresh approaches to address issues in new and innovative ways that deserve the support of this committee. For example, the Engineering Directorate has been moving to restructure its activities to address new classes of problems. It is restructuring them to deal with a number of cross-disciplinary engineering activities, and to develop closer links between universities and industry while maintaining support for established fields of engineering.

In reviewing the budget, I was pleased to note the increased support being given to the new Engineering Research Centers Program initiated last year. The increase of $15 million to a total of $25 million in fiscal year 1986 is an important step signalling the seriousness with which the program is being pursued. This is a substantial increase when compared to other areas of engineering and other programs of the National Science Foundation. It represents a determination on the part of the National Science Foundation to support this innovative approach to cross-disciplinary engineering research, providing experimental capabilities not available to individual investigators and a focus for research on engineering systems such as manufacturing, materials processing, and communications. It addresses the education and training of students and the improvement of the interaction between industry and the universities.

The NSF budget proposals are noteworthy in the additional support it provides to emerging and critical fields of engineering. Research in the process of engineering design, systems integration, automation, and emerging technologies such as biotechnology deserve the committee's support. These emerging fields of engineering are planned for a 12.6 percent increase in fiscal year 1986 over fiscal year 1985.

Among the areas that are planned for increased support, is application of computers in engineering. Computers are revolutionizing processes of engineering design and manufacturing. They provide new tools which are transforming design theory and methodology in all fields of engineering. Typical of the promising new approaches in the NSF budget is an attempt to increase support in emerging fields such as light wave technology.

The plans of the Foundation to provide increased support for Presidential Young Investigators in Engineering, bringing the total to 250, is an important step forward in providing research support to young faculty members and enticing them to remain within the academic community.

Ultimately, the purpose of the support for engineering research in the university community is not only to reap the benefits of the new knowledge that results from engineering research, but also to support the education and training of new talent to meet national needs. Our technological edge depends upon the availability of individuals of high quality, trained to perform at the cutting edge of engineering systems knowledge. In the past few years we have had a dramatic increase in the undergraduate enrollments in engineering schools. The young people of this nation are taking to engineering. They are among the brightest students entering universities, as evidenced by standing in high school classes and SAT scores. We now have a remarkable opportunity for increasing the population of U.S. students at the graduate and doctoral levels in engineering in our universities.

We should seize this opportunity because we have experienced a serious decline in the number of Ph.D. candidates in engineering schools. Today we are graduating only about 3,000 engineering Ph.D.'s. About one-half of these are foreign nationals. While it is important for the United States to offer education and training in engineering to students from other countries, many of whom remain here, we need to make a stronger effort to encourage U.S. students to pursue engineering education through the Ph.D. level. The very large and excellent group of undergraduate students provides us with an opportunity to do so. While there is a slight increase in the support for graduate students in engineering of about 3.5 percent, my feeling is that this is inadequate to meet the needs for engineering talent at the cutting edge.

Lastly, I would like to comment briefly on the issue of instrumentation and equipment. It has been widely noted that the research needs in both science and engineering for instrumentation and equipment far outpace that which is available. In engineering research, it is increasingly necessary for universities to have access to very expensive instrumentation and equipment if forefront research is to be conducted and if students are to be trained in the research which is dependent upon the availability of such instrumentation. A recent survey by the National Science Foundation completed in December 1984 on academic research equipment revealed that 90 percent of the university departments surveyed reported an inability to conduct critical experiments due to lack of needed equipment. Only 16 percent of equipment and instrumentation systems in the 1982 national stock in the various fields that were surveyed were classified as state-of-the-art.

General under-capitalization of equipment and instrumentation is a most serious problem, and a problem that is not the responsibility of the National Science Foundation alone. For FY 86 an increase in equipment and instrumentation to support engineering research of approximately 20 percent is planned. This is encouraging, however, my feeling is that the problem needs to be examined more broadly, and a national approach to the under-capitalization problem is urgent.

To summarize, it is my view that the FY 86 budget for the National Science Foundation is sound. It moves the support for engineering research ahead significantly. The approaches of the National Science Foundation to its engineering research responsibilities are new and innovative. The programs being proposed warrant the full support of this Committee.

STATEMENT BY DR. DAVID A. HAMBURG, PRESIDENT, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Mr. Chairman and Members of the Subcommittee:

INTRODUCTION

Thank you for the opportunity of submitting this statement as part of your hearings on the National Science Foundation budget request for Fiscal Year 1986. This subcommittee has a distinguished record as a strong supporter of scientific and engineering research and education and it is a personal privilege for me to present my views to you.

In beginning my statement, first let me say just a few words about the American Association for the Advancement of Science—or the AAAS as it is commonly known—of which I am currently-elected President. Our members are about 136,000 scientists and engineers; as affiliates we have 285 other scientific, engineering and technical societies and organizations—with a total membership of around five million.

AAAS publishes the journals Science and Science 85, the latter being a high-quality general science magazine written for the interested layperson. Finally, the Association also is active in a broad variety of activities in public policy and public understanding of science and technology.

STATEMENT OUTLINE

Today I shall comment on a number of topics which provide a general setting for considering the NSF's budget request. Here is my roadmap: Overview of research and development—nationally and in the Federal Government; Key international comparisons in science and technology; Science, technology and the economy; International science and technology; NSF commentary; Summary.

OVERVIEW OF RESEARCH AND DEVELOPMENT

By any measure the United States invests large sums of money in research and development; the national total for 1984—public and private—is estimated to be about $98 billion. For the past several years this total has been increasing at a rate of about 11 percent per year so it is probably not a bad guess that the 1985 total will be something around $109 billion. Yet, as I will show later, numbers alone do not tell a complete story.

For the past four decades, the United States has supported substantial investments in research and development. These investments have been made for much the same reasons that President Truman stated before a Joint Session of the Congress on September 6, 1945, only three weeks after war's end, when he said:

"Progress in scientific research and development is an indispensable condition to the future welfare and security of the Nation. No nation can maintain a position of leadership in the world of today unless it develops to the full its scientific and technological resources. No government adequately meets its responsibilities unless it generously and intelligently supports the work of science in universities, industry and in its own laboratories."

Presidents who followed Truman—Democrat and Republican alike up to and including President Reagan—have worked with the Congress during their Administrations in building strong Federal backing for research and development. This backing has taken the form of establishing science-and-technology-based organizations, providing budget growth and taking a wide range of actions in science and engineering education, patent, tax and anti-trust areas.

The private sector—inlcuding industry, the universities and non-profit organizations—has likewise responded to the challenges identified by President Truman. Appendix 1 shows how the relative shares of Federal and non-Federal support of national R&D have varied over past decades and how the total in current and constant dollars has changed during the same period. After declining as a proportion of the national total in the 1950s, the non-Federal share has risen steadily since 1960. Beginning in 1977, the non-Federal and Federal shares became equal at fifth percent each. By 1979 the non-Federal share had inched ahead and gradually increased to a 54-46 percent margin which has held for the past four years.

Why should the public support research and development?

This is a policy question more frequently discussed in terms of a specific R&D program or area; however, since there are several new Members on the Subcommittee I hope you will not mind if I briefly re-state the general case for public support of research and development. First, and quite obviously there is the R&D which must be done to support the special needs of the public and distinctive responsibilities of government—e.g., defense, public health, environment, etc.

Less obviously, the overall benefits to the nation of much—but not all—long-range R&D often exceed the benefits to the organization that pays for it. Thus, competitors can benefit from corporate R&D investments by using the new knowledge generated to their own benefit. And since consumers may also benefit from lower prices and improved quality, the benefits of successful R&D may not necessarily lead just to increased corporate profits.

Further, corporations must properly consider profitability strategies and avoid what might be considered excessive R&D expenditures or R&D work that is not obviously connected to principal business interests. All in all, this has led many to conclude over time that investment by the private sector in R&D cannot meet our national needs—and particularly in basic research. This line of thinking leads to the argument for public sector support for Federal R&D as a major component of a total national effort in R&D—particularly in basic research.

A second, and related, major reason for the special role of the Federal Government in R&D arises from the highly risky nature of R&D investments. One cannot be sure that any one research effort, or any small group of such efforts, will pay off. For example, in the new product development area the private sector faces odds in which only two or three of every one hundred innovative ideas becomes successful in the market place.

Comparable problems of riskiness exist in the governmental arena. However, probabilities of success are greatly enhanced when the aggregate of R&D projects and alternative paths is enlarged. In one of the critical technical and political decisions of this century, Nazi Germany chose one path—a blind alley—in its search for a nuclear weapon while the U.S. achieved success by following several parallel paths as insurance.

The upshot is that private investment in R&D—particularly of a long-term, uncertain payoff nature—are frequently discouraged by high risk considerations. Communications satellites and computers are but two examples of the Federal Government taking the lead where initial risks were high, technologies were uncertain, and markets were in uncharted waters. However, both sets of industries also clearly demonstrate that Federal leadership does not imply long-term Federal domination.

All of this leads to a clear conclusion that Federal suport of R&D has been and will continue to be an important investment in the future. The overall benefits appear to be large—and as will be discussed in later sections, the economic and technological benefits have worldwide significance. Generally, we believe that research and development should be supported strictly on the merits as a long-term investment.

A look at total Federal R&D for fiscal year 1986 compared to 1985 shows big increases in defense R&D, decreases in non-defense R&D, and virtually flat basic research

First, to clarify nomenclature, all of my references to FY 1986 budget numbers and comparisons are in terms of budget authority. Among the key observations are these:

Conduct R&D is up from $50.4 billion in FY 1985 to $58.2 billion in FY 1986. This is an overall increase of 15.5 percent.

The big increase, of course, is in defense. Department of Defense military R&D is up from $32.1 to $40.1 billion, an increase of $8 billion or 24.8 percent.

On the non-defense side, the story is much different. Total nondefense R&D slips slightly in FY 1986, from $18.2 billion to $18.1 billion, a decline of about 1 percent.

NOTE.—These figures have not been adjusted for anticipated inflation. If one assumes a 4 percent rate of inflation (about what the Administration seems to be forecasting), the decline in non-defense R&D becomes more significant.

Much of the decline in non-defense R&D results from these cutbacks: (−5.7 percent) Department of Health and Human Services; (−2.6 percent) Department of Energy; (−6.1 percent) Department of Agriculture; (−18.6 percent) Department of Transportation; (−26.0 percent) Department of Commerce—especially the National Oceanic and Atmospheric Administration; Various—Other smaller agencies.

NOTE.—Funds were appropriated by the Congress for FY 1985 which would have permitted MIH to make 65,000 grants awards. However, the Administration proposes to hold the number of awards to about 5,000 in both years and to carry over FY 1985 funds to reduce the amount requested for FY 1986. Hence, the decline results in HHS R&D as shown above.

Set in the context of these kinds of declines in the non-defense area, NSF's 6.9 percent increase looks rather good.

However, on the negative side, total basic research is virtually flat—up 1.1 percent from $7.8 billion in FY 1985 to $7.9 billion in FY 1986. This is a significant decline in constant dollars, assuming a 4 percent inflation rate. One of the major factors in this trend is the HHS/NIH story, as noted above. This is a serious problem. HHS supports about 39 percent of total Federal basic research, while the NSF supports about 17 percent and the Defense Department, about 12 percent.

Summary point: The amount of U.S. investment in R&D has been and remains large—although there are problems as suggested by certain key comparisons, domestic and international

Defense/non-defense comparisons: fiscal year 1981–1986

To obtain a somewhat longer perspective than is given by a comparison of FY 1986 and 1985, I will briefly show several key comparisons for FY 1986 and FY 1981, the beginning of the Reagan Administration.

From FY 1981 to FY 1986, total non-defense R&D is down 8 percent in current dollars and is down 21 percent in constant 1972 dollars—a substantial real decline.

For the same period, total defense R&D is up 129 percent in current dollars and is up 67 percent in constant dollars—showing strong real growth.

Total basic research is up 47 percent in current dollars and is up 23 percent in constant dollars, with defense accounting for about one-fourth of the increases.

Except for the NSF and NIH, all non-defense agencies of government have experienced real reductions in their R&D budgets during the FY 1981–1986 period, some of them quite serious, e.g., the Alcohol, Drug Abuse and Mental Health Administration (ADAMHA).

These trends reflect clearly stated Administration policies and priorities during the past few years. While R&D in the aggregate—including basic research—has been treated very well indeed, it is necessary to raise several cautionary points.

First, if defense and space R&D continue to increase their shares of the total Federal R&D budget, it will be very difficult to support other non-defense R&D even at current levels.

Next, as one looks ahead to the growing family of very large-scale technological commitments, such as the space station and space-based anti-satellite defense systems, the squeeze on available R&D resources could become severe. The combined costs of even a few of these very large projects could add up to many tens of billions of dollars.

Finally, it is surely not unreasonable to be apprehensive about substantial displacement impacts upon resources for general science. Further, there could be severe displacement effects on the supply of scientists and engineers, on university-based research, and upon the applied research that leads to innovation and economic competitive strength.

KEY INTERNATIONAL COMPARISONS

It is clear that very large numbers are seen when we examine total R&D spending in the United States. Further, as close study of the most recent (1982) issue of the National Science Board's Science Indicators shows the United States still maintains overall scientific and technological leadership in its absolute investments in R&D, contributions to scientific and technical literature, positive balance in R&D-intensive trade, and the sale of technical knowledge.

However, we cannot examine the large U.S. numbers in isolation. As was noted in the Science and Technology report of the Commission on an Agenda for the Eighties, "the sheer size of the U.S. economy results in larger R&D expenditures than those of other countries," but "taking these data in comparative perspective raises serious concerns about international economic competition."

Let me cite several of these comparative perspectives.

The data in Appendix 1 of my statement shows that from the mid-1960s until about the mid-1970s U.S. R&D was on a plateau; only in 1976 did a distinct growth period begin. And while the U.S. was on this plateau, other nations were experiencing substantial real growth. One indicator of the strong, relative growth of others is this fact: In the 1970-period, total U.S. R&D was twice that of France, West Germany, the United Kingdom and Japan combined; by the 1980-period, the combined R&D totals of the same countries equalled that of the U.S.

This observation relates directly to the data in Appendix 2 which shows that, as a percentage of GNP, total R&D spending in the U.S. declined steadily from 1964 until a modest turnaround began in 1979. The comparable numbers from Japan, West Germany and the U.S.S.R. increased steadily and substantially during the no-growth/relative decline of the U.S.

Perhaps of more direct relevance to the competitive international economic scene is the information in Appendix 3 which shows the ratios of civilian R&D expenditures to GNP for selected countries. The substantially larger ratios for Japan and West Germany are significant and substantial in terms of their international economic performance.

Closely related, and worth noting in terms of international business and economic competition, are the following data: In recent years, Japan has allocated only about 2.4 percent of government R&D to defense, West Germany about 9.4 percent and France about 33 percent—compared to about 65 percent for the U.S.

Another facet of the FY 1985–1986 no growth in Federal basic research (shown in the previous section) is demonstrated on page 199 of Science Indicators: 1982. There is a distinct and substantial underinvestment by the U.S. in the advancement of knowledge (basic research) compared to some of our international economic competitors—our major European allies and Japan. Further, as shown on pages 47–48 of Science Indicators and pages 12–14 of National Patterns of Science and Technology Resources: 1984, there were real declines in the amount of U.S. basic research from the late 1960s until the mid-1970s. At that time both the Federal Government and industry began to make constant dollar increases. While the industry component has continued to experience sustained real growth in the range of 7 percent per year, the Federal Government's support has been much less steady—ranging from a decline of 1 percent in 1982 to a 7 percent increase in 1984.

Clearly we are a nation which still maintains a scientific and technical leadership role in the world, although just as clearly others are catching up. As a cautionary note to this leadership appraisal, I would summarize several Science Indicators observations. U.S. inventive activity appears to have decreased relative to some foreign competitors. More directly troubling is that the U.S. share of world exports in R&D-intensive products continue to decline. And, as previously noted, other nations continue to increase their R&D investments and activities relative to the U.S.—particularly in civilian R&D. This is not a set of circumstances and trends which warrants complacency.

SCIENCE, TECHNOLOGY, AND ECONOMY

Maintaining our scientific and engineering strength with appropriate balances between defense and non-defense R&D is central to powering our economy and providing for our national security.

Economists and other scholars have given much attention to understanding the factors that contribute to economic growth—although the number of such researchers focusing specifically on scientific and technological considerations is not large. Even so, such individuals as Edward Denison, Edwin Mansfield, Theodore Schultz and William Nordhaus have reported results which suggest that scientific and technological advances, or the growth of knowledge, have been a major source of economic growth over both short and long periods since 1929.

These findings have powerful implications for policy—both in the public and private sectors. In going to the heart of the matter, investment in building the stock of knowledge—in science, technology and education—appears to be at least as effective as investment in capital stock (production equipment, tooling and physical plant) in powering economic growth. Such ideas have important implications for the entire range of budget and tax issues now before the Congress, some of which appear as part of the on-going industrial policy debate.

As I have already noted, the significant R&D budget increases in the Federal sector of the past few years have been primarily in military R&D. And these very large increases are for the most part being allocated to weapons development. This is an important point because it is very much an open question as to how much "transfer" to the private sector and long-term economic growth results from military R&D, especially weapons development.

This defense/non-defense division inevitably becomes part of the policy debate on the respective roles of the Federal Government and the private sector as the international competitiveness topic has assumed greater and greater importance in recent years. and taken together with the earlier cited international comparisons—particularly the greater focus on civilian R&D by our strongest economic competitors—we must be quite careful about assuming that "all is well" because aggregate Federal R&D amounts are increasing at impressive rates.

An essential aspect of "appropriate balance" must deal with the possible long-term implications of real no-growth or declines in civilian Federal R&D. Moreover, the possible reallocation of large numbers of scientists and engineers to military purposes could have serious negative consequences for the private non-defense sector.

Another central feature of "appropriate balance" deals with time horizons. There are enormous pressures at work in this country—in both the public and private sectors—for short-term payoff. Often such pressures are antithetical to the time requirements of an effective research and development program. Indeed, I would go as far as to say that a worrisome flaw in our basic thinking, our reward systems, our policy making structures, and in the ways we work and live are bound up with "the short-term syndrome."

It has been widely argued in the general media as well as in academic settings that differences in perspective on "the short-term syndrome" divide much of Japanese industrial thinking from that of U.S. counterparts. For example, it has been reported that U.S. corporate research in some industries has lagged behind that of Japan mainly because of U.S. preoccupation with short-term payoffs. It was argued that financial pressures worked against the long-term orientation needed for successful scientific work.

Pressing this point, Leighton Smith, and Arthur Anderson & Co. partner with long experience in Japan, has argued that labor relations are important but that the key to Japanese success is their orientation to a long-term point of view. Smith asserts that until U.S. boards of directors decrease their emphasis on the current quarter's results and free up management from "fire-fighting" to concentrate on markets down the road, American industry's markets will continue to be eroded by the Japanese.

The same concerns can be expressed about Federal research and development. For example, within the recent past there has been heavy pressure placed upon the Environmental Protection Agency to focus much of its R&D upon short-term problems. This is understandable in a mission-oriented agency, but it can be overdone. Such trends demand careful scrutiny by senior officials in government and in the private sector; unchecked, they would sow the seeds of future failure on a broad scale.

Industrial innovation

In recent years, concern about the trends described above—domestically and internationally—has taken the form of "the industrial policy debate." A specific focus of this debate has been on the rate of U.S. industrial innovation, which is seen by some as declining. Further, some have seen negative consequences of the perceived innovation decline in terms of U.S. economic growth, productivity improvement and international trade competitiveness.

This debate is very complex and is often polemical rather than analytical. We need a lot of objective inquiry from different perspectives to sort out these deeply interrelated questions and provide a stronger basis for wise policy. It may well be that we need additional ways to increase and encourage R&D investment; hence, the direct connection to today's hearing. But Federal increases are only one part of a much larger set of possible actions. Still, there is strong Federal interest in these issues.

In fairly rapid order, the following areas have been addressed in legislation by the President and the Congress:

A major R&D-related initiative of the 97th Congress was the Economic Recovery Tax Act of 1981 (P.L. 97-34). Provisions of this law are intended to stimulate private R&D investment and charitable donations of equipment to universities.

In the 98th Congress, P.L. 98-462, the National Cooperative Research Act of 1984, called for the rule of reason to be applied in anti-trust law with respect to joint R&D ventures.

In a landmark effort, P.L. 98-620 provided amendments to Patent and Trademark Laws which give exclusive licenses to private contractors for patents arising from R&D work they do for the Federal Government.

In the area of university-industry-Government cooperation, Congress has done two things of note: (1) enacted the Stevenson-Wydler Technology Innovation Act which authorized the establishment of generic technology centers to encourage universities and industry to work together and, (2) The NSF has been encouraged to support on a modest scale university-industry cooperation.

Taken together, this is an impressive set of actions on a broad front. And while I am familiar with the jurisdiction problem in Congress, I hope your subcommittee will continue in the future to follow this area closely, providing whatever coordination and overview it deems appropriate. Much is at stake and the effort to understand these problems more deeply is certainly in the national interest.

INTERNATIONAL SCIENCE AND TECHNOLOGY

One of the main features of the domain of science and technology in the decades following World War II has been the major presence of the United States on the international scene in a variety of ways—in international governmental bodies, in international scientific groups, and as individuals. A principal tenet of our foreign policy has been the encouragement of full U.S. participation in the international scientific and engineering communities—communities which transcend political boundaries and social and cultural traditions. Sharing the results of scientific research and engaging in a wide assortment of international exchanges between and among developed and less developed nations alike have become central characteristics of these communities.

The growing interrelatedness of the world, a rising consciousness of the imperative to view many problems globally and plain self-interest in keeping open our windows on science in the rest of the world—all these factors point toward higher priority on activities and programs in support of international science and technology. However, I regret to say that there has been some slippage in recent years. Those who care about American leadership in world science, as well as American contributions to the general well-being, should take an interest in this problem.

In the largest of our international scientific and technical programs—that of the Agency for International Development—there seems to be ambivalence: on the positive side, considerable interest in the scientific quality of specific projects; but apparently little interest in a broad, coordinated approach to scientific cooperation that would involve working closely with other government agencies and the scientific community. In 1978 Congress made a valiant effort to bring about a more effective coordination process for Federal international scientific and technical activities—the so-called Title V role of the State Department which included an annual report. However, the annual reports have been a very low priority effort at State—under Domestic and Republican Administrations alike—and few independent observers would declare the process or the reports effective.

I find the lack of strong focus and the paring down of our international participation especially regrettable as I look at the very special opportunities and problems emerging in the developing world. These nations are increasingly coming to recognize that science and technology offer great hope in meeting their developmental aspirations for economic and social progress. And they have great respect for American strength in science and technology. It would be an immensely grave mistake to forego these opportunities for American leadership and contributions to the general well-being. U.S. participation in selected bilateral arrangements with countries meeting a set of prescribed political criteria is a necessary but far from sufficient response to this great challenge.

Aside from humanitarian desires for generally making this world a better place for all, there are additional reasons for arguing that it is in the best interest of the United States that we help in the application of science and technology for Third World development. Trade data shows that we export more goods and services to Third World countries than to Western Europe and Japan combined. We have trade surpluses with these countries—a rarity elsewhere in the world.

For the long-term, and in addition to the more traditional aid programs, we should be placing strong emphasis on assisting Third World countries with science-transfer and the development of effective educational structures and systems. We should be establishing a wide variety of cooperative research efforts and exchanges focused on Third World interests and problems. And where Third World countries and their scientists and engineers have the interest and capabilities we should encourage their active participation in the larger global issues that transcend national boundaries. The famine in Africa provides a powerful stimulus for change in economic development strategy with a large role for U.S.-African scientific cooperation.

UNESCO

I would like to make a few remarks on UNESCO. Let me begin by observing that the National Academy of Sciences concluded that among all UNESCO programs ($47 million), the science programs ($14 million) rank high in terms of effectiveness and usefulness to the United States. It is my understanding that the Department of State has identified $2.7 million of its own funds to be used to cover significant U.S. international scientific activities that would go unfunded due to the U.S. withdrawal from UNESCO. Otherwise, we have been unable to discern what, if any, coverage there will be for the programs formerly carried out by UNESCO.

There is definitely nothing in the NSF budget request for this purpose. It would appear that, previous assurances notwithstanding, the UNESCO withdrawal will lead to valuable work not being done. If the Congress is so inclined, the NSF could be given responsibility for managing the funds for the selected activities. It has a distinguished track record in managing and supporting international scientific activities.

East-West relations in science and technology

As special topics under international science and technology, I would now like to address two subjects: (1) Support for the International Institute for Applied Systems Analysis (IIASA) and (2) U.S.-U.S.S.R. bilateral relationships in science and technology.

IIASA

We at the AAAS believe that IIASA effectively promotes cooperative research among established scientists—and young scientists as well—from East and West and some Third World countries on a number of global problems. We further believe that this is done in a context that advances overall U.S. national interests. For such reasons, AAAS has recently joined in a consortium of U.S. non-governmental scientific associations to support the work of IIASA.

The current Administration's position on IIASA is that core or institutional support not be provided from the U.S. Government, but that IIASA is free to solicit and compete for grants and contracts from U.S. science agencies, subject to State Department approval. This is a step in the right direction from an earlier and more restrictive position but it does not go far enough; a small nucleus of assured funding is highly important to provide a basis for an effective long-term program.

Therefore, I would place a recommendation before the subcommittee: that you consider recognizing the importance of IIASA both to the advancement of international science and to U.S. national interests and that you authorize institutional support at a level of approximately $1 million per year, about one-third of the former level. We judge this would be enough to assure a viable program when supplemeted with project support by governments and support from the private sector.

U.S.-U.S.S.R. Relations

Relations of all kinds between our two countries have been on the decline since the late 1970s, beginning with the invasion of Afghanistan. In 1982, three of the eleven bilateral agreements between the U.S. and the U.S.S.R. in the areas of science and technology, space, and energy were allowed to expire—with neither party seeking renewal. Since then, relations have remained chilly and, following the KAL incident in 1983, the President also suspended the transportation agreement.

However, in June 1984 the President gave an important address in which he endorsed scientific and scholarly exchanges with the Soviet Union. He announced that he was authorizing renewed cooperation under the existing agreements, and that the agencies responsible for these programs should develop more active programs. He did not suggest the re-establishment of those agreements which had been allowed to expire. Since then, the progress has been modest but real.

Given the above cited progress, the findings of a June 1983 report from the State Department to the Congress which found positive benefits to the U.S. from the U.S.-U.S.S.R. bilateral S&T program, and the recent initiative between the National Academy of Sciences and the Soviet Academy, I would ask this subcommittee to explore with the Administration the reinstatement of the bilateral S&T agreement as part of a constructive and forward-looking move in improving U.S.-U.S.S.R. relations.

SCIENTIFIC COMMUNICATION AND NATIONAL SECURITY ISSUES

I would like to take a few moments to commend the role that the NSF has played in trying to clarify the responsibilities of U.S. scientists under the Export Administration Regulations (EAR). Ambiguous language in the EAR on the export control of technical information has caused much concern and confusion within the scientific and engineering research communities over the past several years.

This confusion centers on the extent to which traditional communication is subject to regulation. I understand that the Office of the General Counsel at NSF has been instrumental in developing a proposal to revise the EAR in such a way as to relieve researchers of the burden of determining whether dissemination of knowledge to foreign colleagues and students could result in prosecution under the Export Administration Act.

The NSF proposal was reviewed and approved by an OSTP Advisory Committee on Scientific Communication late last year. The main idea of the proposal is to establish a General License authorizing the unrestricted dissemination of scientific and technical information not otherwise subject to contractually agreed upon national security or proprietary limitations. A General License would also apply to dissemination of information that is consistent with any such contractually-imposed controls, once all restrictions have expired or have been removed.

Limiting application of export controls to cases where a researcher violates contractual obligations is consistent with the recommendations of a panel convened by NSF in January 1984 and those of the Corson Panel convened by the National Academy of Sciences in 1982. Both panels concluded that the Government should rely primarily on contractual rather than regulatory restrictions in the rare instances where some information dissemination restrictions on scientific research are appropriate.

In concluding this section, I again would like to commend the NSF for taking the lead in airing these vitally important issues and in developing a workable solution to the problems encountered by the research communities in interpreting the EAR. Achieving a proper balance between legitimate national security interests and those related to freedom of scientific communication requires a fine sense of judgment. I hope the proposal, as approved by the OSTP Advisory Committee, is adopted by the Department of Commerce quickly so that the chilling effect of current EAR language on scientific communication can be vanquished.

COMMENTARY ON THE NSF BUDGET REQUEST

I do not intend to discuss specific budget numbers or line items in any detail. However, I am prepared to make a number of comments about the budget and will also provide several recommendations for you to consider.

As I noted briefly in the overview of R&D section, it seems clear that the NSF budget—at the aggregate level—fared well in a climate of strong pressures to reduce spending and to come to terms with large deficits. The Administration is to be commended for adhering to its course in recent years of strongly supporting investment increases in the research programs of the Foundation. The budget increase this year of nearly 7 percent—primarily for research—is encouraging in an otherwise no growth picture for basic research, as was pointed out in the overview.

Those of us in the scientific community have been heartened by the vigorous way in which new Foundation Director Bloch has moved into his job and by the open way he has made himself available to advice from a wide variety of sources. He is a person of exceptional distinction. And while it may be possible to take exception to some of the organizational, program and budget decisions, it appears to be a management environment in which resonable people may differ but still come to an understanding on reasonable terms.

Science and engineering education

Now I would like to state my views on science and engineering education. This is the organizational and program area where we find ourselves greatly puzzled and, as are many in the scientific and engineering communities, increasingly restive about the limited progress being made by the Foundation in "getting its act together." Again, since there are new members on the subcommittee, we would like to review a number of key points and highlights covering the past five years.

Background

Starting in 1980 with the publication of Science and Engineering Education for the 1980s and Beyond (prepared by the NSF and the Education Department), there has been a large number of studies, reports and books, all of which, in one way or another, point out the urgent need for the nation to strengthen its science and mathematics education. All of them have stressed that it is a time for action, and that this action must come from every level: local, regional, state and national. They have also stressed that there is so much to be done, that there are important roles to be played in both the public and private sectors.

While there are differences on just what the Federal role ought to be, there seems to be no disagreement that there is a substantial Federal role. Furthermore, there appears to be widespread agreement that the NSF and the Department of Education both need to provide some resources, as well as constructive leadership.

The Congress has decided, along with the Administration, that the major role of the Department of Education in relation to science and mathematics education is to take the form of block grants to the states, and the NSF is to remain as the chief Federal instruments for influencing and providing leadership nationally in science, mathematics and engineering education.

Among the national studies, one of the most important was commissioned by the National Science Board itself. Called the Commission on Precollege Education in Mathematics, Science and Technology, its findings were made available in "A Report to the American People and the National Science Board," "Educating America for the 21st Century: A Plan of Action for Improving Mathematics, Science, and

Technology Education for all American Elementary and Secondary Students." The objectives was to insure that the achievement of the American students would be the best in the world by 1995. The National Science Board endorsed the report.

Where do things stand?

That clarion call for action has not, however, been followed up with any notable vigor by the NSF itself. This, despite firm notice from Congress since 1983 that, like it or not, the NSF was going to have the science education function. It seems reasonable to suppose that the NSB Commission report would be the first step in a thoughtful and energetic response to national needs as set forth in the report itself and which were strongly emphasized by Congress.

First, for the past several years NSF has not spent the money made available to it by Congress for precollege science and mathematics education.

In FY 1983 $15 million was available but only $1.1 million was spent.

In FY 1984 $68.6 million was available (from new appropriations and carryover) but only $37.2 million was spent.

In FY 1985 $87.0 million is available (from new appropriations and carryover) but $31.4 will be carried over to FY 1986.

No one is suggesting that NSF spend money recklessly, but surely over such a span of years it would be possible to expend these relatively small amounts thoughtfully and usefully, when the public demand and the fundamental requirements are so great. Of course, the NSF and the nation itself suffered a serious blow when the Education Directorate was essentially destroyed in the first year of this administration. Surely the time is at hand for recovery. This is an urgent national need. No other entity, public or private, can replace the NSF in science education.

There is real urgency for NSF to set in motion the planning steps on how to organize itself and conduct effective programs according to a coherent strategy in keeping with the Board mandate. Congress itself was troubled by this state of affairs and, apparently losing patience, last year decided to require the NSF to get itself on track in education. It appropriated $2 million to enable NSF to seek outside help in setting specific goals, short-and long-term, in aligning priorities, and in budgetary and organizational planning.

As of now, no contract has been set in place and it is unknown when such a plan will finally emerge. This is a matter you may wish to inquire into. It is possible that your subcommittee may wish to place this topic on your oversight agenda. We deeply believe that continuing Congressional interest will be essential to achieve the national goal in the critical field of science education. Your efforts can only be a positive help to Mr. Bloch as he sorts out the pieces of this puzzle and provides the necessary leadership.

Other actors in science and engineering education

The wide range and depth of problems in science and engineering education identified in the previous section have drawn a great deal of attention and action on the part of many organizations—public and private. I am heartened by the growing variety of the responses by states, by school districts all over the country, by corporations, by private foundations (such as my own), by science museums, and by professional associations such as the AAAS.

Each of these entities tends to focus on special elements of science and engineering eduction. For example, a number of corporations have chosen engineering schools as their focus; the states have been revising curriculum and teacher requirements and standards; and the AAAS has concentrated its energies and programs—with substantial private foundation support—or pre-college science and mathematics education.

Because they do not usually gain as much public attention as some of the other activities, I would like to point especially to the growing roles of science and technology museums in science education. All over the country, science museums are experimenting with new forms of reaching out to the people in their areas, and especially to the children. We at the AAAS have found the museums to be uniquely valuable partners in the realm of science education; thousands of our members are now participating in volunteer programs with science museums all over the country.

It is possible that some could conclude that because of this array of activities in science, engineering and mathematics education, there is a diminished role for the NSF. We strongly differ with such a point of view. Indeed, as I stressed earlier, the need for the intellectual leadership and coordinating role of the NSF is stronger than it ever was. No state or foundation or corporation can replicate the special kinds of talent that the NSF can marshall in order to develop the long-range strategies and programs necessary to cope with the urgent problems that face us on a national scale.

NSF international science and engineering programs

Although I have discussed general international science and technology matters at some length earlier, I would like to focus this part of my testimony directly on NSF international programs. Appendix 4 contains a summary of what NSF considers as its international activities.

A review of why NSF supports international activities in science and engineering reveals two reasons: the first relates to the enhancement of science and engineering in the United States and maintaining a position of leadership in critical areas of science and technology through close contracts with centers of excellence in other countries; the second relates to U.S. foreign policy interests and the role of science and technology in advancing those interests.

Often the nature of the research enterprise requires a strong international component for certain problems which are global in nature such as research on the weather, oceans, climate and various biological, geological and chemical cycles. In yet other cases, international collaboration is necessary to provide U.S. scientists with access to specific resources—physical, biological or geological available only in other countries. Finally, in some fields of research world leadership is found in the form of people and facilities in other countries; the ability to collaborate and communicate with these leaders is essential to the strength of U.S. science and engineering.

In support of foreign policy goals, international science and engineering activities can contribute to strengthening our national defense, to improving the economies of developing nations as earlier discussed, to reducing East-West political tensions and improving general understanding, and to strengthening ties with our allies. Increasingly the Executive Branch has used bilateral science agreements as a form of cooperation with other nations.

For all these reasons, maintaining close and varied links between science and engineering in the U.S. and other countries is vitally important to both domestic and foreign goals. The question, then, is how international activities fare in the proposed NSF budget.

First, as Appendix 4 shows, the total seems to be rising modestly; however, it is important to note that the small parts of the budget related to cooperative science efforts under a large number of bilateral agreements administered by NSF actually have been reduced in FY 1986. This turns out to be a few hundred thouand dollars per country for a total of about $7 million. I find this priority rather difficult to reconcile with the overall importance of these cooperative agreements. The $7 million comes from subtracting the National Academy of Sciences amount (for administering special agreements with the Peoples Republic of China, for example) of a little over $4 million form form the $11.4 million estimate for FY 1986.

Today, I am not prepared to address in detail other elements of the international program—such as the composition of the disciplinary area research projects which NSF estimates at $81.5 million for FY 1986. In view of the intimate way the world is now bound together, and the growing concerns about American leadership, the subcommittee may well find it useful to inquire into this matter at a subsequent date.

In summary, I raise a cautionary word as to whether the budget reflects the kinds of priorities which should be accorded the international area—or whether we see in another way some of the "pullback" across-the-board in international science and technology I referred to earlier.

Programs for women, minorities, and the handicapped

First, and very important, we wish the applaud Mr. Bloch for his concerted efforts to increase the amount of data available in the NSF needed to monitor its equity efforts. In terms of specific actions, we think it very positive that the following actions have seen or are being taken:

The establishment of one new program and one new activity last year that address needed areas: (1) Research Opportunities for Women, a program for new women investigators who have not been a recipient of previous federal research support as a project director: and (2) Research Facilitation Awards, an activity that would augment grants—to provide additional support that might be required by a disabled scientist, engineer or student on a grant—to adapt scientific equipment, or obtain specific assistance to accommodate to a disability.

The support of programs in FY 1986 that have special impact on minorities, women and handicapped.

The continued emphasis in every directorate to address equity concerns.

NOTE.—For a more complete review of the special programs in this area, please see Appendix 5.

On a less-than-positive note, however, I need to point to the absence of programs at the college level in Science and Engineering Education. This absence greatly hampers efforts for minorities, women and handicapped persons because there are retention problems at this level which cannot be addressed under the present program structure. At the same time, we need to expand the use of the option to involve undergraduate students from these groups in research funded out of the regular research grants.

Further, there is significant underfunding of the Research Opportunities for Women Program. Even a doubling would not begin to address the level of proposal pressure being experienced. Four hundred and forty applications to the program in FY 1985 will lead to the granting of seven awards.

More generally, we hope to see improvements in the Directorates in their efforts to increase participation by minorities, women and physically handicapped persons. We would like to see the efforts to bring these groups into the scientific mainstream integrated into the on-going operations of the Foundation. Until that integration takes place on an adequate scale, we need strong targeted programs that build toward enduring institutionalization.

Finally, we hope that the reorganization of the National Science Board means growing attention to equity issues within the board context of NSF's concern for talent. The largest pool of talent available to do the work of science in the next century is the one whose potential to contribute has been ignored too long—minorities, women and handicapped persons. The nation must fully utilize this great pool of talent in the future.

Program on ethics and values in science and technology

In the course of reviewing a large, multi-million dollar budgt, it is all too easy to overlook small programs which have been set aside to make way for new initiatives or for projects which have been judged to be of higher priority. One such item is the NSF Program on Ethics and Values in Science and Technology—or EVIST as it is called. I deeply regret its absence.

EVIST has provided support for research studies, workshops, conferences, symposia and publications on a variety of important topics. The goal of the program has been to provide an explicit focus on the ethics and values associated with the acquisition and use of scientific and technical knowledge. It has represented a symbolic commitment by the NSF to the principle that scholarly research has much to contribute to our understanding of contemporary controversies involving science and technology. One of the great tasks of our time is to work toward the judicious use of technology. We are entering new and difficult terrain. Ethical problems must be addresed.

EVIST is the only program in the entire Federal Government which has provided sustained support for work on ethical and value issues arising from biomedical research as well as science and technology more generally. A brief review of recent EVIST awards illustrates the importance of the research topics it has supported:

Ethical and value conflicts in food safety decision making.

Ethical implications of trade secrecy, patents and related property controls for science and technology.

Risk-setting, risk-taking, and the introduction of new technologies.

Ethical issues in approaches to research on mental illness and women.

Ethical responsibilities and practice in the use of animals in biomedical and behavioral research.

Ethical issues in human gene therapy.

Moral decisions in discovering and controlling occupational health hazards.

The AAAS and other professional groups and academic centers have set up science and ethics programs over the past decade, many of which have been stimulated by the EVIST program. For example, the AAAS has focused increasing attention on the ethics and values area through its Committee on Scientific Freedom and Responsibility; moreover, we have incorporated such ideas into the fundamental objectives of the Association. I find it rather ironic that this very success of the EVIST program is one of the major reasons being stated by NSF for its discontinuance; it is as if the undisputed success of the NSF in helping to establish scientific centers of excellence in chemistry or mathematics were used to justify withdrawal of NSF support.

In effect, the NSF position is that supporting the EVIST-type research should now be a private sector responsibility. In part they are correct; foundations, universities, corporations, and associations such as our own should be supporting work in these areas. But is not correct to conclude that these issues are totally a private sector responsibility. We believe that the NSF can and should continue to provide an intellectual leadership role and act as a catalyst for other organizations—a role it has performed well and often.

We believe that the Federal Government—and the NSF—cannot afford to look the other way when crisis and conflict arise from ethical and value issues in science and technology. In the absence of sustained and vigorous scientific inquiry, we are more likely to be left with rhetoric, polemic and anecdote as the basis for solving such problems.

I hope the subcommittee will agree. Specifically, we hope that in your review of this budget you will consider continuation of the EVIST program in its modest form.

Social, economic, and behavioral sciences

These program areas have been near the center of discussion of NSF budget reviews in recent years. It is encouraging that the social and economic sciences areas has received a healthy increase for FY 1986 of $5.4 million to a total of $33.9 million; this is a rather better showing than was achieved by the behavioral sciences where the increase of about three percent probably means some loss in constant dollars.

We hope the subcommittee will continue its support for these science areas; congressional actions have been vitally important in recent years in keeping research in these fields alive.

After all, what is more important in the world today than a deeper understanding of conflict resolution? Similarly, recent studies from the Institute of Medicine, National Academy of Sciences, clarify the great importance of behavior for health. Progress here requires strong research in behavioral science and collaboration with biomedical science.

SUMMARY

Mr. Chairman, again let me thank you and the other members of the Committee for this opportunity to present my views. In my appearances before congressional committees over the years I have developed a high respect for those of you in the Congress. It is reassuring to observe at first hand the deep understanding held by those in Congress on the vital set of relationships between science, technology and the well-being of our nation and the rest of the world.

Finally, I would like to make several concluding observations and recommendations in summarizing my views:

(1) In looking at the overall R&D picture, the U.S. remains strong and the general state of science and technology is reasonably healthy. My major qualifier is that we must be very careful not to tilt too far toward military R&D in relation to non-defense R&D. Close watch on this balance and its long-term implications is warranted.

(2) Examination of key international indicators suggest that other nations are gaining rapidly on the U.S. in vital areas of science and technology—and particularly in areas related to performance on the highly competitive international economic scene. This is an important policy domain where Congress has been particularly active in recent years; your continued oversight in this area is strongly urged.

(3) Greater national focus—public and private—must be placed on longer-range perspectives vis-a-vis short-term outlooks.

(4) The importance of international science and technology calls for your close attention in the form of budget and policy reviews—particularly for cooperative scientific and engineering programs, including those between the U.S. and the U.S.S.R., and especially those involving the developing countries.

(5) Another special feature of international science and technology which we commend to your attention is the delicate and intricate balancing of interests between national security and freedom of scientific and engineering research objectives.

(6) Overall, the budget for the National Science Foundation is a good, strong product. In a time of fiscal pressures, it represents a sound investment in the nation's future. Only in science and engineering education do we seem to have views that differ sharply from those of the Foundation; in the other areas, noted below, we suggest several modest changes for your consideration.

NSF does need to give science and engineering education a higher priority, get itself organized and formulate a strategic set of programs which will meet urgent national needs.

In the context of the overall importance of international science and technology, the downward direction of cooperative science budgets at NSF is not the way to go.

While much progress has been made, the NSF needs to maintain a strong focus on integrating the concerns of women, minority and handicapped persons into the mainstream of research directorate activities.

The EVIST program should not be terminated; it is far too valuable in its catalytic role, espeially considering the modest level of funding at about $1 million per year.

This concludes my statement. Thank you.

STATEMENT OF THE ASSOCIATION OF SYSTEMATICS COLLECTIONS AND THE ASSOCIATED NATURAL SCIENCE INSTITUTIONS

The Association of Systematics Collections and The Associated Natural Science Institutions are pleased to provide testimony in conjunction with the authorization hearings for the National Science Foundation. We believe in, and support, the mission of the Foundation. The combined constituencies of our two organizations represent over 90% of the institutions and individuals in the United States that study whole organisms. Together, we represent between 8,000 and 10,000 individuals, over 30 scholarly societies, and nearly 200 institutions containing over 680,000,000 biological specimens.

The pure research supported through the National Science Foundation is an investment in our future—society's overhead—that assures that practical questions can be answered in the future, in a timely and credible manner. Our statement focuses on those biological research programs supported by NSF that emphasize studies of whole organisms and the institutions that provide the facilities necessary to undertake this research, *e.g.*, biological collections, laboratory facilities, research equipment, and computers. Of particular importance to our constituents are the Systematic Biology and Biological Research Resources Programs in the Division of Biotic Systems and Resources and the Anthropology Program in the Division of Behavioral and Neurosciences. However, significant funding in our community has been awarded from programs in Stratigraphy and Paleontology, Biological Oceanogrphy, and International Programs. Most of these programs are administered in the Directorate of Biological, Behavioral, and Social Sciences. Our discussion of the significance of Anthropology Program is presented on page 5 of this document.

Before addressing the specific role these NSF programs play in our community, we would like to make two comments: the first concerns the role of museums and botanical gardens in research and graduate education; the second addresses the present status of the systematic biology community.

Research and graduate/undergraduate education in the biological sciences are not undertaken exclusively in universities. Slightly over 21% of those receiving funds awarded from recognized programs in NSF work in museums or botanical gardens, while museums and botanical gardens are responsible for maintaining nearly one-third of the biological collections. Almost 50% of the researchers in systematic biology rely on collections at institutions other than their own for specimens used in their research. Therefore, congressional action concerning replacement of deteriorating and obsolete equipment in colleges and universities must be applied to museums and botanical gardens with established research and graduate programs (the latter through formal relationships with degree granting institutions).

Systematic biology—the study of the relationships of organisms—is a dynamic science that serves as the foundation upon which other biological disciplines are built and inquiries pursued. With the application of technologies from such diverse fields as mathematics, chemistry, physics, engineering, and computer science, systematics is enjoying a renaissance. Because names given to species by systematic biologists imply relationships with other organisms, the names are not fixed. As biologists learn more about organisms, the organism's name may change to reflect this new knowledge. Why is this important? Simply, the ability to achieve and repeat results in all research in other branches of biology (*e.g.*, ecology, physiology, behavior, genetics, biochemistry) depends on identification and classifications provided by systematic biologists as a consequence of their studies of species and species relationships.

We believe that Congressional recognition of the pivotal role systematic biology plays in these three areas is extremely important to the future of biology in the United States, and the world. In support of the reauthorization of the NSF we describe the central position NSF programs hold to the larger research and development investment of our Federal government; the relationships such investments in research have on undergraduate and graduate education; and the influence research investments have on the communication of science to respond to societal needs.

These three parameters are closely related and their separation is not as discrete as implied by the facts that follow.

RELATIONSHIP OF NSF FUNDING TO OTHER GOVERNMENT PROGRAMS

From the research community's perspective, during the five years from 1978 through 1982, a total of $165,000,000 (or 433,000,000 per year) was received by research museums and similar institutions in systematic biology. Of this amount over 82% was provided by Federal agencies; the National Science Foundation provided slightly less than 40% ($65,000,000 or $13,000,000 per year). Private sector support accounted for about 10% of the total funding. These funds take into account support for research as well as the necessary resources to undertake and sustain the research programs.

The Natonal Science Foundation is the *only* Federal agency that is charged with underwriting these pure research activities. The Foundation's outstanding record of suporting quality research programs is, to a great extent, based on its utilization of the peer-review system through which the community itself participates in the selection and award process. All other federal agencies that invest in research directed to answering specific questions pertinent to the missions of their agencies must rely on the output of the pure research community before they can adequately address the problems facing them.

RESEARCH SUPPORT AND GRADUATE/UNDERGRADUATE EDUCATION

The relationship between the National Science Foundation and education at the graduate/undergraduate levels is less evident but extremely important. Research funding provides employment for students at both the graduate and undergraduate levels making it possible for students to cover their educational costs. More importantly, however, the work provides a remarkable educational experience from the standpoint of the scientific community. What better way to learn how to do research than to work on a research project? Since NSF support emphasizes pioneering studies that open new avenues of inquiry, this research internship is a vital supplement to traditional course work and a necessary final step in training new biologists.

Three-fourths of the graduate students in systematic biology have indicated that completion of their graduate training was dependent upon their receiving external financial support through teaching, research, or curatorial assistantships. Over 20% of the students working on Masters degrees and nearly 40% of those working on doctoral degrees received necessary financial support through research assistantships.

Support by the National Science Foundation enables many natural history museums and botanical gardens to conduct important predoctoral graduate programs. As degree granting universities transfer the trusteeship of natural science collections to museums and botanical gardens their graduate students in systematic biology, minerology, and anthropology, conduct their dissertation research projects at the museums and botanical gardens, the collections of which are supported by the Foundation. Graduate students contribute to the maintenance and preservation of systematic collections and they add significantly to the challenging intellectual climate in these institutions.

The quality of undergraduate education is also enhanced as a consequence of the research investment. Those receiving research funding, including the research assistants, are generally far better qualified to communicate their subject because they must know their subject extremely well in order to qualify for such funding. This is particularly important when looking ahead to the next generation of researchers in our discipline. Nearly 80% of the professionals in systematic biology today chose their field because of the influence of a key personality or a key course during high school or undergraduate college. People in our profession decide to do what they do because of their love for the organisms—not because they will make a lot of money. Active researchers are crucial to the recruitment and training of new researchers.

We are certain that the research enterprise, in conjunction with the educational roles of the sponsoring institutions (*e.g.*, universities, colleges, museums, and botanical gardens) provide the cornerstone of science today, and more importantly the future. The research programs at the National Science Foundation are particularly important in catalyzing this process in our community.

RESEARCH SUPPORT AND COMMUNICATION OF SCIENCE

Communication of science in our community is accomplished in four ways: 1) publications, 2) instruction, 3) exhibits, and 4) responding to specific questions. Whether the subject is genetic engineering, environmental conservation, acid rain, species or habitat preservation, animal husbandry, or agriculture, basic knowledge of organisms is crucial to rational decisions.

Given the dominant influence of NSF supported research in our community, it is fair to assume that a large percentage of the published articles and books are a direct consequence of the NSF investment. Between 1978 and 1982 individuals in our community published over 20,000 peer-reviewed articles and over 1500 books. Over 40% of our constituent institutions sponsored publication series designed expressly to communicate the results of research studies. And over one-fourth of these institutions support publications that are specifically designed to communicate science to the public.

Instruction is accomplished in the traditional classroom model primarily associated with secondary schools and colleges or universities, as well as through short courses commonly offered by museums and botanical gardens that are designed for the interested public. Irrespective of the model employed, the quality of the educational experience is tied to the underlying research programs at the institution.

Exhibits play an extremely important role in communicating research activities to the public in museums and botanical gardens. Gone are the days when a natural history exhibit was comprised of a stuffed animal. Today our constituents must maintain a dynamic exhibits program that communicates concepts in the natural sciences in order to meet the expectations of a sophisticated public. To keep the public aware of contemporary science, ideas for exhibits programs are derived from the research components of these institutions. Again, the research supported through the Foundation is very important to this process.

Finally, specific inquiries from the public concerning the natural sciences represent a significant contribution to the communication of science to the public. Inquiries range from "How do I get rid of the bats in my attic?" to "What organisms would be found in a particular area?" to "What is the name of a particular organism?" In any case, the answers to these questions are directly related to the research activities of our community.

In conclusion, to fulfill our responsibility to the public, it is essential that the Foundation provide support for long-term research projects that result in taxonomic revisions and monographs. This research emphasis will synthesize current knowledge of groups of organisms, thereby making higher level, synthesis-oriented, inquiries more cost effective in such fields as ecology, pest-control management, genetic engineering, etc. To complement such revisionary studies, it is essential that large scale floral and faunal surveys be implemented. Besides identifying the biota that have been heretofore unknown, data derived from such surveys will allow the community to be far more responsive to the public questions we are being asked to answer. In both cases the public investment will simultaneously serve to stimulate young students to select whole-organism biology as their profession.

Currently, those institutions (particularly museums and botanical gardens), that have a commitment to research in organismic biology, have extreme difficulty capitalizing specialized equipment that is necessary for more than one research project, *e.g.*, scanning and transmission electron microscopes, computers, frozen tissue facilities. In most instances such equipment cannot be justified on the basis of a single research proposal, yet in the absence of such equipment, researchers in these institutions are no longer competitive for support. Likewise, support is needed for those collection facilities in major institutions that provide services for researchers throughout the United States. In many instances external demands on an institution far exceed the curators' capacity to respond. To discontinue such services would severely curtail whole-organism research and yet the institutions are finding it more difficult to fulfill this professional responsibility.

ANTHROPOLOGY

Finally, a word about collection based anthropology, which at NSF is in the Division of Behavioral and Neural Sciences. Museum specimens that represent man's heritage are deteriorating rapidly and badly need increased support. The administration's budget for anthropology is in the $5 million dollar range but less than 10% of that amount is invested in the preservation and conservation of natural history collections.

Anthropological collections, the material evidence of vanished and disappearing societies, are being consumed by neglect, albeit benign, in our institutions. At the root of this neglect is the lack of funds.

The stores of America's research museums must be protected and preserved: protected from the insects, bacteria and rodents that are devouring inadequately stored textiles and leather items; and preserved from the sunlight that fades the colors of dyes and paints made from extinct plants. Space is also a critical factor. Making breakage a constant threat, insufficient cupboards force delicate pottery or fragile basketry to be stacked and then crowded together. And large items, such as primitive machinery, boats and carts, are at risk of damage when they must be moved through narrow corridors and stairways.

Yet why is this material evidence so vital? Why is it more than mere curiosities that belong in the nation's attics? Material evidence provides a remarkably objective way for scientists to study man's variety, limits and possibilities. The history of humans and human societies, the evolution of human cultures and their diversity can be derived in several ways. Oral tradition and the written record are two obvious ways. But a third way is through observation, cataloguing and study of the objects made and used in a society. Oral and written history may reflect the biases of their originator, their translator, and their interpreter. Material evidence has the advantage of objectivity at least as a source; only the interpreters may impute their own biases to objects.

New scientific technologies for interpretation, such as radioactive carbon dating, classification in computer data bases, and accessibility through modern communication systems have put a premium on material evidence as a scientific research resource.

And in the future, we may expect that more developments will render material evidence even more valuable. However, the rapid deterioration of items when storage facilities do not have proper space, humidity, termperature and light control means that many of these irreplaceable items may be lost to future scholarship. Moreover, when museum budgets do not support well-trained personnel, sufficient in number, items are not accessible for research.

An additional problem is posed by a growing increase in value of archeological and anthropological artifacts in the commercial art market. This factor renders them liable both to theft and to sale by financially hard-pressed museum directors. These two threats to the stock of material evidence available for scientific research in this country are closely tied to lack of funding: security systems and personnel are expensive; an adequate financial base would obviate the necessity to sell irreplaceable items to support salaries and other programs.

Thus, in order to preserve our artifacts and museum treasures so that we and our descendents may solve some of mankind's riddles, we must make an investment—an investment in saving the material evidence of the past, and thereby understanding ourselves, our predecessors and, possibly, our future.

We are grateful to the Committee for giving us this opportunity to express our views. If the Committee should desire further information or data, please contact my office.

UNIVERSITY OF NEBRASKA—LINCOLN,
COLLEGE OF ENGINEERING AND TECHNOLOGY,
Lincoln, NE, February 6, 1985.

Senator EDWARD ZORINSKY,
U.S. Senate, Washington, DC.

DEAR SENATOR ZORINSKY: I would like to call to your attention a matter of vital importance to the engineering and scientific community at the University of Nebraska-Lincoln and throughout the nation. Specifically, I am concerned about the lack of an authorization bill for the National Science Foundation for the past four years.

The National Science Foundation is essential to the Nation's scientific and engineering basis. The health of our science and engineering schools is at the heart of U.S. competitiveness in global markets. NSF plays a very essential and vital role in this area.

Although NSF has continued its programs in the absence of authorization bills, its ability to be responsive to the needs of the scientific and engineering enterprise has been hampered. The lack of clear and cohesive direction from Congress hinders NSF's ability to concentrate on its mission. NSF must be able to proceed with a clear and forward-looking mandate to maintain our present and future scientific and technology basis.

Part of the problem is a jurisdictional dispute between Senate committees: Labor and Human Resources Committee chaired by Senator Hatch and Science, Technology and Space Subcommittee chaired by Senator Gorton of the Commerce, Science and Transportation Committee. Both bodies have produced NSF authorization bills which have not reached the Floor of the Senate. This problem has remained unresolved in the Senate for four years. At a time when the country must be concentrating its efforts and limited federal resources on retaining and expanding its technological leadership to compete with determined rivals such as Japan, we cannot allow problems such as this—however legitimate—to impede the best possible use of agencies such as the NSF.

Hopefully, this issue can be resolved in the very near future so that the NSF can again concentrate on its mission. We look to your leadership to help resolve this important issue.

Sincerely,

S.R. LIBERTY,
Dean.

TUFTS UNIVERSITY,
February 22, 1985.

Hon. ALBERT GORE, Jr.,
U.S. Senate, Washington, DC.

DEAR SENATOR GORE: What with all that is happening to the R&D programs in the federal budget, you have precious little time, no doubt, to worry about a program with annual budget of one million dollars. But, this is something very special, I assure you.

The new director of the National Science Foundation has decided to eliminate its research program on Ethics and Values in Science and Technology (EVIST) at the end of this fiscal year. This small program is being sacrificed at a time when its humanistic and ethical studies of science and technology have become widely recognized for their quality and social importance.

What is this country coming to? Don't we understand the lessons of the past, when a madman like Hitler took science and technology to the death camps? Do we walk away from these implications? Is this the message for a generation of young scholars who are trying to keep us from blowing ourselves up?

Besides being Provost/Academic Vice President of Tufts University and Jean Mayer's second-in-command, I am also a teacher of German culture and spend as much time as possible reminding our students of the moral responsibility of the scientist and engineer. Please help us keep this very modest EVIST program in the budget, as a symbol of the government's commitment to this purpose.

Sincerely,

SOL GITTLEMAN,
Academic Vice President/Provost.

HARVARD UNIVERSITY;
DEPARTMENT OF PHYSICS;
Cambridge, MA, February 25, 1985.

Senator, ALBERT GORE, Jr.,
U.S. Senate, Washington, DC.

DEAR SENATOR GORE: The budget of the National Science Foundation is about to be submitted to you. It will show that the NSF Director wishes to zero out the EVIST program in NSF entirely. I urge you to insist, during the hearing, on reinstating the program and its budget, and I take the liberty of attaching a brief list of arguments on behalf of EVIST.

Respectfully,

GERALD HOLTON,
Mallinckrodt Professor of Physics, and Professor of History of Science.

Enclosure.

SOME ARGUMENTS ON BEHALF OF PREVENTING THE ABANDONMENT OF THE NSF RESEARCH PROGRAM ON ETHICS AND VALUES IN SCIENCE AND TECHNOLOGY (EVIST)

1. The abandonment is an abrupt and hasty decision not made on the merits. Even members of the National Science Board have said they were not consulted and

at least one has complained that it may be done chiefly to direct money into the fast-growing, big Directorate for Engineering (up by 122%, FY 80-86).

2. The EVIST program is relatively small ($1 million p.a.) and young (about a dozen years old), but already it has triggered a long string of successful research results that have contributed to policy formation by industrial managers, legislators, and academic researchers. Such studies range from secrecy in science to privacy in the electronic age, from the question of the start of "personhood" to the problem of heroic maintenance of life, from measures of the "quality" of science to the role of technical expert witnesses before courts, Congress, and regulatory agencies. These are not concerns that will go away!

3. Thanks to EVIST support, there now exists a visible commitment to be concerned with the ethical and moral impacts of the nation's scientific and technical advance. Conversely, a brutal zeroing-out of the EVIST program will send out the clear signal that scientists, NSF, and the Congress are unconcerned about such matters.

4. This is bound to play into the hands of those who oppose or misunderstand scientific and technical progress—the Luddite elements that have in the past dearly cost us scientific research support.

5. Thanks to EVIST there has grown up a whole cadre of well informed and interdisciplinarily competent researchers. This will largely and suddenly disappear if industry and universities see the sudden discontinuance of this essential research support.

6. Thanks to EVIST (and initially financed by it, but now spun off to the private sector) journals were founded that publish some of the research results in the field. One of these is the quaraterly Science, Technology, & Human Values (STHV); it indicates the ecumenical nature of the field that among authors who have been published in STHV are scientists, philosophers, industrialists, clergymen, and such legislators as Orrin Hatch and Doug Walgren.

Institute for the Medical Humanities,
The University of Texas Medical Branch,
Galveston, TX, February 14, 1985.

Hon. Albert Gore, Jr.,
Committee on Commerce, Science and Transportation, Washington, DC.

Dear Senator Gore: First I want to extend my hearty congratulations on your election to the United States Senate, and your selection as a member of the Committee on Commerce, Science and Transportation. I have long admired your work on science and technology issues and am relieved and delighted to see that you will have a committee assignment which will permit you to continue your efforts.

But I also write to you to plead for your support for the Ethics and Values in Science and Technology program in the National Science Foundation. As you know, the new leadership at NSF has proposed striking the EVIST program from the NSF budget. I believe this is shortsighted in the extreme, and will result in a significant deterioration in the quality of public discussions on ethics and value issues in science and technology.

I write to you especially because in your former position as chairman of the Subcommittee on Investigations and Oversight of the House of Representatives Committee on Science and Technology, you have pioneered the constructive use of testimony on ethics and value issues by experts in the humanities and the sciences.

I thought it was worth mentioning to you that a number of the people who have appeared before you to talk about ethical issues in science and technology had acquired much of their knowledge through the support of grants from the EVIST program. It was true in my case, and for many others including Leroy Walters and Clifford Grobstein. Without EVIST's support, humanists will not have the time or resources to collaborate with scientists, nor will scientists be able to work with humanists to do anything approximating the extent now made possible by EVIST.

Despite the remarkable impact of EVIST, it is a tiny program as far as federal dollars go. It's annual budget has typcially been about a million dollars a year. That is one fifteen-hundredth of the projected NSF budget for 1986. Surely a nation that values public discussion of the ethical implications of science and technology can afford to spend less than one-tenth of one percent of the NSF budget on a consideration of those issues.

I know there are many important demands on your time and energy, but I hope that you will see fit to take up the cause of EVIST and insure that the public policy discussions it has so often enriched can continue to be nourished by its contributions.

If I can be of any assistance whatsoever, please do not hesitate to call on me.

Sincerely,

Thomas H. Murray, Ph.D.,
Associate Professor.

Vanderbilt University,
Nashville, TN, March 2, 1985.

Hon. Albert Gore, Jr.,
U.S. Senate, Washington, DC.

Dear Senator Gore: As you are aware, the present Director of the National Science Foundation, Mr. Erich Bloch, is proposing to eliminate funding for the NSF Program on Ethics and Values in Science and Technology (EVIST). My purpose for writing you is to inform you of my opposition to this proposal and to ask that you assist in any forthcoming efforts in the Senate to assure the continuation of the EVIST Program.

Let me share with you, from the perspective of a Vanderbilt faculty member concerned with the soundness and quality of engineering education, my view of the positive impact of the EVIST Program:

This program has had an outstanding record of uniting members of the scientific and engineering communities with members of the social science, legal, and humanities communities in their mutual desire to seek clarification of the ethical and value dimensions of science and technology. Not only has the program supported original research by capable scholars and interdisciplinary teams, but it has provided the opportunity for diverse groups from both industry and universities to convene for the purpose of sharing insights and experience in these matters.

The EVIST Program has existed within NSF since 1975 and currently receives annual funding of $1 million. Its impact during this period, in my judgement, far exceeds expectations for such modest funding. (The present allocation represents approximately one sixteen-hundredth or six-hundredths of a percent of the total NSF budget.) At present there is no other Federally supported program of research in this domain.

My personal experience with the program dates from 1977, shortly after returning to Vanderbilt from a leave-of-absence supported by a NSF fellowship on "Science Applied to Societal Problems." As a consequence of this experience, and having begun some collaborative activity in the areas of Technology and Values, Engineering Ethics, and Technology-Policy, I was called upon to evaluate research proposals submitted to EVIST. I was also a participant, along with my colleague Prof. Michael Hodges of the Philosophy Department, in the EVIST-supported National Project on Philosophy and Engineering Ethics. This project alone has had national impact in the development of case studies, text books, and materials of value to teaching and research in these areas.

As a member of the University and engineering research communities, with interests in materials science and engineering, I applaud the efforts of Mr. Bloch to promote closer ties between industry and the universities, and to promote interdisciplinary approaches for research. It seems, therefore, doubly ironic that NSF is prepared at this time to discountinue the EVIST program. First, EVIST has an outstanding record of support for interdisciplinary research. Moreover, it is a program which can contribute to resolution of the problems, both conceptual and normative, that are likely to emerge from such industry-university collaboration.

Sincerely yours,

Barry D. Lichter,
Professor, Materials Science and Management of Technology.

American Chemical Society,
Washington, DC, March 13, 1985.

Hon. Slade Gorton,
Chairman, Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, DC.

Dear Mr. Chairman: The American Chemical Society welcomes this opportunity to present its views on the proposed FY 1986 budget for the National Science Foundation. Our comments focus on the NSF Chemistry Division, instrumentation, facilities, the Directorate for Science and Engineering Education, and the Directorate for Scientific, Technological, and International Affairs.

NSF CHEMISTRY DIVISION

The American Chemical Society urges that increased funding for chemical research be given a high priority in the deliberations of the Subcommittee. In proportion to its contribution to the economy, chemistry has been and is currently underfunded.

Chemistry is entering a new era of productive inquiry as a result of advances in the understanding of the elemental steps of chemical change, and the existence of powerful instrumental techniques. The February 22, 1985 issue of Science magazine is devoted to exciting areas of chemistry which are indicative of this potential. However, chemistry's contribution to the Nation will not be fully realized unless the base funding support for the chemical sciences is increased and this increase is sustained.

Chemistry is a fundamental, central discipline from which many other sciences flow. The chemical sciences have been instrumental in the development of U.S. society, and they likewise will play a significant role in our Nation's future. These sciences are not only the backbone of today's chemical and allied products industries, but they also underlie the high technology industries, such as computers, electronics, robotics, and biotechnology. An estimated forty percent of the U.S. GNP is derived from the chemical sciences if food production and energy technology are taken into account. The chemical industry's shipments abroad yielded a trade surplus that averaged $10.6 billion per year from 1979-1983, making the U.S. chemical and related products industry a strong international competitor. Advances in these industries, and subsequent scientific and technological leadership by the U.S., will depend upon continued support of research in the basic chemical sciences as well as experienced personnel trained in the chemical and allied sciences.

While the Chemistry Division is the major source of funds for basic chemical research at NSF, other Divisions of the Foundation support related activities. The following remarks will be limited to the Chemistry Division, but these comments, in principle, could be extended to all NSF funding for the chemical sciences.

The NSF FY 1986 budget for the Chemistry Division is slated for a 7.0 percent increase. However, in order to address the significance of the proposed budget, the real magnitude of the increase needs to be examined in relation to prior funding patterns and future growth potential. It is important to recognize that although we are in a time of budget austerity, we must not lose opportunities for scientific advancement. These opportunities are available to us in the subfields of chemistry and in interdisciplinary research involving chemistry.

The FY 1986 budget is best understood if placed in a historical context. The funding history of the Chemistry Division in current and constant dollars is presented in Appendix I. Budget appropriations for basic research in chemistry have increased 2.5 times during the period 1973 to 1985. However, in estimated constant 1972 dollars, this increase represents an uneven growth pattern in funding of the Division which averages out to only a four percent annual increase. These figures indicate that basic chemical research has simply maintained a marginal growth when inflation is taken into consideration during this period. Maintenance or even low-level growth is insufficient when considering the contributions that the chemical sciences have made and will make to American society.

In the ACS analysis of the FY 1985 and 1986 budgets for the Chemistry Division, we have subtracted out the amounts earmarked for the two new initiatives—Chemistry of Life Processes and Materials Chemistry. This calculation indicates that the costs of the new program initiatives have been partly absorbed by the established subactivities of the Chemistry Division [Appendix II]. The Division will continue to deny high quality proposals in these established areas because of insufficient funds. Since the number of investigators receiving scientific research project support will remain at approximately 875, these new initiatives will make funding decisions more difficult starting in FY 1985.

Broad support for basic research across subfields is vital to the advancement of chemistry since it is impossible to predict where discoveries will occcur. The consequence of not pursuing all good research translates into lost opportunities that in the long-term will be detrimental to the health of science and to the economy as well. Moreover, support by NSF of basic research is important to the health of chemistry as a discipline, particularly at academic institutions since the Chemistry Division in FY 1984 provided forty-one percent of the federal support for basic chemical research performed at universities and colleges.

The ACS favors setting research priorities and understands the need to cut back programs in order to reduce the federal budget deficit. However, the Society believes that the proposed funding level for the NSF is by no means the optimum. The opportunities before us in the chemical sciences would justify—even in a time of fiscal restraint—a far larger amount than is proposed.

Other scientific organizations have recognized the importance to the Nation of supporting promising chemical research areas. The National Academy of Sciences panel, which briefed the Office of Science and Technology Policy on chemistry in 1983, noted three such research areas in which a substantial infusion of federal funding would allow the exploration of new territory on the cutting edge of chemical science. These frontiers are: (1) chemical reactivity, (2) chemical catalysis, and (3) chemistry of life processes.

Only one of these areas, chemistry of life processes, has been targeted for specific NSF funding. The chemistry of life processes involves the application of basic chemistry techniques and principles to the solution of molecular life processes. Failure to fund sufficient research on the chemical aspects of biology could cost the U.S. its leadership in biotechnology and applied biology.

The NAS panel suggested that the chemistry of life processes be funded at a level of $25 million per year, with $10 million of this yearly amount available as grants. NSF funding for the Chemistry of Life Processes initiative is significantly below these recommended amounts. This means that many excellent research proposals in this emerging area will be inadequately funded or will not be supported at all.

In the Society's view, NSF plays a key role in ensuring the exploration of opportunties in basic chemical research in areas that are not pursued by the mission agencies. The Society believes that NSF cannot adequately perform this function within the constraints of the proposed FY 1986 budget. Consequently, ACS urges that funding for chemical research be given a high priority in the Foundation's FY 1986 budget.

INSTRUMENTATION

Achieving progress in the research areas receiving Foundation support depends on access to modern instrumentation. The survey conducted in 1982 by the ACS Committee on Science—"Instrumentation Needs of Academic Departments of Chemistry"—found that the average age of the instrumentation in U.S. chemistry departnents was between eight and nine years [Appendix III]. In the experience of laboratory managers, retaining most instrumentation beyond seven or eight years is unwise. Given new developments in the field, instruments continuously become scientifically and technologically obsolete. The ACS survey results also indicated that fifteen percent of the equipment at smaller chemistry departments, and nine percent at major ones, was not fully operational in 1982. Therefore, given the age of the equipment, maintenance becomes an increasing problem.

The ability of chemists in academe to conduct research at the cutting edge of science is limited by the age and condition of their equipment. The ACS estimated that the one hundred major U.S. chemistry departments would need $83.2 million for instrument purchases; the 470 smaller chemistry departments would need $65.5 million. The Society projected that with the addition of maintenance, technical support, and other ancillary costs, $500 million may be required to update and maintain equipment in a manner necessary to ensure progress in chemical research. The need, as estimated by the ACS study, is so great that both private sources and government programs must be utilized to address this problem.

The ACS is aware of the National Science Foundation's efforts to survey the need for and to fund instrumentation purchases. The Society especially commends the Foundation for assisting both research and undergraduate institutions in this area.

The ACS Office of Science Policy Analysis recently conducted a survey of all the current federal programs funding instrumentation purchases. As a result of the survey, the Society noted that federal program managers were not always aware of the working details of federal instrumentation programs other then their own. The implications of this situation are that, without an exchange of experiences and information, designing the best possible instrumentation program is a difficult, if not impossible task. The magnitude of the instrumentation problem for chemistry and other disciplines is so great that a more coordinated effort is necessary. The American Chemical Society strongly urges the Foundation to strengthen the interactions of the Interagency Working Group on Research Instrumentation so that governmental efforts in this crucial area could be made more efficient and cost-effective.

The American Chemical Society also supports the NSF's continuing commitment to increase access to supercomputers for academic research scientists and engineers. In 1984 the ACS Task Force on Large-Scale Computing completed a review of the kinds of critical chemical research problems that can be studied within a reasonable amount of time only with the use of a supercomputer. The Task Force concluded that supercomputers are an important component in sustaining the health of chemistry.

FACILITIES

In the past, campus "bricks and mortar" has been the responsibility of the public and private sectors. Academic institutions have obtained funding from a variety of sources—alumni funds, corporate grants, foundation grants, and federal governments awards. The American Chemical Society believes this should be the continued method of obtaining facilities funding. No one should expect the federal government to solve single-handedly the facilities problem.

The exact magnitude of the facilities problem is not known, but there is a large and growing recognition of the need for funds to build and restore scientific research and education facilities. The ACS recommends that the NSF assess the country's current and projected need for new or renovated scientific facilities. Once such a nationwide assessment has been done, it can serve as a guideline for the consideration of future requests. The National Science Foundation already administers the data collection for instrumentation needs at universities. A similar data base should be assembled and maintained to assess future needs for university scientific facilities.

Although it is difficult to determine the scope of the facilities problem, it needs to be addressed now. One less costly method of dealing with the immediate problems in this area would be to initiate a renovation program rather than fund new starts for R&D and education facilities. Renovation funds should be used for modernizing and necessary safety features, such as fume hoods, needed in both research and teaching laboratories. The American Chemical Society urges that a renovation program be considered for funding in the FY 1987 NSF budget to address the problem of deterioration and obsolescence of existing facilities. Further, the Society endorses some form of merit-based review for such a federal renovation program.

In this time of attempting to control and reduce federal budget deficits, the university community needs to acknowledge and endorse merit-based review as a proven mechanism for and an essential component of choosing high quality projects. In the mid-1970's to early 1980's, the merit-based review process received close scrutiny and only minor changes. Currently, this process is still the most equitable way of guaranteeing careful scrutiny of and excellence in federally-funded basic research projects while assuring the best use of scarce federal funds. Consequently, ACS recommends that some form of merit-based review be established to select the highest quality facility projects.

SCIENCE AND ENGINEERING EDUCATION

The American Chemical Society supports the overall goals of the NSF Directorate for Science and Engineering Education and stands ready to offer its assistance. Specifically, the ACS commends the Directorate for emphasizing the science and mathematics taught in the middle and elementary schools of the U.S. The ACS recognizes good teaching at these levels to be of crucial importance to the development of a scientifically-informed citizenry, and the Society has established a Pre-High School Science Office to work with other concerned groups and associations on the many problems in this area.

The need to support precollege education in science and mathematics has been clearly recognized in a series of reports produced by a number of prominent national commissions. The ACS's own "Tomorrow" report published in April 1984 explicitly enumerates the Society's concern for adequate support of both teacher preservice and inservice training and for the development of new materials for grades K through 12 science education [Appendix IV]. Regrettably, it is in these two areas that the Directorate is, in effect, "losing" funds through the budget deferral process. The ACS is sympathetic to the management concerns of the Directorate, but deplores the need to defer funds from year-to-year. The Society is confident that the Directorate will continue its status as the lead agency in the area of science, mathematics, and engineering education. In order for the Directorate to accomplish this, ACS recommends that: the FY 1985 current plan of $82.0 million be set as the base for the Directorate's FY 1986 budget and that the $31.5 million in deferred funds be returned to the Directorate budget. This additional support should be allocated to the Materials Development and Research subactivity and the Teacher Enhancement and Informal Science Education subactivities, increasing their allotments to $38.4 and $40.8 million, respectively. Our recommendation is that the overall FY 1986 budget for the Directorate of Science and Engineering Education be set at $113.5 million. In making this recommendation, the ACS intends that new money be added to the $31.5 million deferral in order not to reduce support for research in the disciplines funded by NSF.

The American Chemical Society recognizes, as does the Directorate, the importance of working in partnership with others and of establishing communication networks in support of excellence in science and engineering education for all levels of students. The ACS stands ready to give its support to the Directorate in expanding and maintaining such networks.

Finally, the ACS is pleased with the continued support of Presidential Young Investigator Awards. The NSF should be applauded for its continued support of Graduate Research Fellowships through its Research Career Development subactivity. However, the American Chemical Society does recommend that some portion of these funds be awarded directly to institutions of higher learning as competitive block grants for support of their own graduate fellowship programs. The effect of currently awarding all funds to individual students is to channel recipients of these portable fellowships into a few prestigious institutions, resulting in an inequitable distribution of funds and a weakening of promising research programs at other universities. Science only thrives through the creative interplay of diverse ideas as expressed through research conducted at a variety of institutions.

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS

At a time when international scientific cooperation is an avenue to world peace and economic development, cuts in the International Cooperative Scientific Activities program in the Directorate for Scientific, Technological, and International Affairs (STIA) are viewed by the ACS as counterproductive. The American Chemical Society believes it is very much in the government's interest to provide support for activities such as attendance at international scientific and engineering conferences, formation of cooperative research and development projects, provision for scientific journals, and reciprocal lecture tours. Support for these activities is the responsibility of a number of federal departments and agencies, but NSF should have primary responsibility, especially in areas involving basic research.

The ACS applauds the Foundation's continued priority under STIA for research support for undergraduate institutions, women, and minority scientists. The American Chemical Society is pleased that funding has doubled for Research Opportunities for Women and that the program is concerned with career reentry.

The National Charter of the American Chemical Society imposes an obligation upon the Society to provide advice to the government in matters of national concern related to its areas of competence. One of the objectives set forth in the ACS Federal Charter is the promotion of research and the advancement of education. With this objective in mind, we hope that our comments will be useful to the Subcommittee in its deliberations on the FY 1986 budget of the National Science Foundation.

Sincerely yours,

Ellis K. Fields, President.

Attachments.

NSF CHEMISTRY DIVISION APPROPRIATIONS HISTORY 1973-1986

[000 omitted from dollar amounts]

Fiscal year	Actual/ proposed	GNP deflator	Constant (1972) dollars
1973	$25,081	1.044	$24,024
1974	26,645	1.125	23,684
1975	32,728	1.246	26,266
1976	34,650	1.332	26,014
1977	40,226	1.424	28,249
1978	43,050	1.520	28,322
1979	45,230	1.651	27,396
1980	51,451	1.776	28,970
1981	57,622	1.953	29,504
1982	61,356	2.093	29,315
1983	67,628	2.176	31,079
1984	79,427	2.259	35,160
1985 (proposed)	87,400	[1] 2.341	37,334
1986 (proposed)	93,500	[1] 2.443	38,273

[1] The GNP deflators for 1985 and 1986 are estimates.

Source: National Science Foundation.

NATIONAL SCIENCE FOUNDATION CHEMISTRY DIVISION

[000 omitted from dollar amounts]

Program title	Fiscal year 1984 actual	Fiscal year 1985 current plan	Fiscal year 1986 proposed	Percent increase 1985-1986
Chemistry of Life Processes [1]	0	$2,000	$3,500	75.0
Materials Chemistry [2]	0	6,800	7,700	13.2
Remaining Chemistry Division	$79,427	78,600	82,300	4.7
Total, Chemistry Division	79,427	87,400	93,500	7.0

[1] Funding from the Biological, Behavioral, and Social Sciences Directorate for the Chemistry of Life Processes: FY 1985, $1.5 million; FY 1986, $1.0 million (estimate).

[2] Figures for funding from the Materials Division are not available at this time.

Source: National Science Foundation.

NSF's Plan To Eliminate Its Ethics in Science Program Opposed

SCIENTISTS, SCIENTIFIC SOCIETIES PROTEST PROPOSED TERMINATION OF UNIQUE PROGRAM ON ETHICS, VALUES; CONGRESSIONAL EFFORT TO RESTORE FUNDING IS ORGANIZED

(By Richard J. Seltzer)

In a proposed federal budget of $938 billion and a requested budget for the National Science Foundation of $1.6 billion, $1 million is pretty small change. Thus, little attention was paid a month ago, even in publications written for scientists, to NSF's proposal in the fiscal 1986 budget to terminate its Ethics & Values in Science & Technnology program (EVIST) by eliminating its entire $1 million budget.

That is changing now, however. An increasing stream of protests from scientists and scientific societies is flowing to Washington, D.C., urging retention of the program. Moreover, an effort is being organized in Congress to restore funding for the program.

"It's a small investment, but it's very, very important as a symbol and for the work it's producing," says Michael S. Baram, professor of health law at Boston University's school of public heatlh. Studies of ethical and value questions raised by science and technology are "an investment any major industrial society should make," he adds. "In light of incidents like Bhopal, we need to deal with these subjects."

EVIST was founded in 1975 in response to growing concern among scientists, the public, the media, and Congress over the ethical and social implications of advances in science and technology. It grew out of a kind of task force started in 1971 in NSF. The task force found that directing research proposals in these areas to regular NSF programs, without a grant program and line item in the budget, did not work. In its decade of existence, EVIST has provided support for research studies, workships, conferences, symposia, and publications on many topics.

The program's funding rose from about $522,000 its first year to a peak of almost $2 million in fiscal 1981, and it since has fallen back to about $1 million a year. These amounts have been supplemented by funding for EVIST projects from other federal agencies, primarily the National Endowment for the Humanities, which granted about $800,000 in 1981. With some small funding from other NSF offices, EVIST projects received total funding of about $2.8 million in that peak year. However, NEH funding in this area has dropped sharply in the past couple of years, with the agency now emphasizing traditional humanities studies. Thus, EVIST projects received less than $1.3 million from all sources in fiscal 1984.

There are two themes to much of the research support, notes Rachelle Hollander, current director of EVIST: ethical or value issues in professional conduct (such as whistleblowing), and ethical or value issues in development and use of new scientific or technological methods for decision making (such as cost-benefit analysis). In recent years, there has been a move to more studies related to public health and safety and environmental health, including occupational health and safety issues. Issues related to engineering also have become more prominent, points out William A. Blanpied of NSF, who directed EVIST from 1976 to 1979.

Many of the current research projects are chemically related. For example, June Fessenden-Raden of Cornell University has received $114,000 for a project on values and toxicological risks. This project is looking at the impact of values on communities that face risks to their environment and health from chemicals in the aquifers that provide their water. The study is also trying to identify ethical and value issues for toxicologists who serve as experts when issues of risk arise. the interdisciplinary research team includes toxicologists, social scientists legal scholars, experts in public administration, and philosophers.

Vivian Weil of Illinois Institute of Technology has received $61,000 for a study on ethical implications of trade secrecy, patents, and related property controls for science and technology. A conference in June, including commissioned studies and analyses, will discuss the impact of institutional arrangements that restrict or encourage the exchange of scientific and technological information.

Meanwhile, Clark University's Roger Kasperson has been awarded $171,000 for a study on ethical issues in identifying and protecting high-risk persons in the workplace. NEH and the National Institute for Occupational Safety & Health have given part of the funds.

The American Association for the Advancement of Science is carrying out an EVIST-supported project on secrecy in science, involving commissioning of papers for publication and holding of seminars. And EVIST is a major source of funding for the Student Pugwash International Conference to be held this June. This conference will bring together students and senior scientists, engineers, specialists in the social sciences and humanities, and executives to discuss several current issues involving the social and ethical implications of science and technology (C&EN, Jan. 28, page 35).

Why has NSF decided to kill EVIST? In NSF's budget proposal and in hearings late last month before the House Subcommittee on Science, Research & Technology, NSF director Erich Bloch described it as a matter of eliminating a lower priority program in a context of overall pressure for budget-tightening. NSF "must make difficult choices in order to minimize the impact on academic science and engineering research activities." Thus, it has to curtail "programs that are not in the mainstream of science and engineering research and education." (Observers agree that EVIST has not been targeted because of any political or ideological motive; but NSF has also drastically cut other policy-related research, including a proposal to pare its office of Policy Research & Analysis from $4.7 million to $2 million.)

Moreover, Bloch says, EVIST has succeeded to the extent that much of the work in the field now has a life of its own and can be carried on without EVIST. And researchers in the field can compete for support from other NSF programs, especially in the behavioral and social sciences. Indeed, he adds, workers in the field should "get into the mainstream of things," and end their "sheltered" existence.

It is hard to find any scientists who favor killing EVIST. The program's supporters take vehement objection to Bloch's explanations. First of all, several observers point out, EVIST has always had a kind of orphan status at NSF, "an anomaly wherever located," not fitting into any department or division because of its unique focus and range of activities. Thus it has been "visible and vulnerable." An attempt was made in 1981 to terminate the program, but then-NSF director John B. Slaughter favored continuing it, with support from scientists and from political leaders such as Sen. Orrin Hatch (R.-Utah).

Gerald Holton, Mallinckrodt Professor of Physics and professor of the history of science at Harvard University, who has been involved with EVIST from the start, stresses that NSF support—intellectual as well as financial—is "vital for maintaining research and discussion" on issues in this field. It represents NSF's commitment to the ethical and social accountability of science and engineering for results of their activities. Termination of EVIST, he and others emphasize, would be a signal that NSF does not consider these issues to be important. University deans and department chairmen would draw appropriate conclusions about supporting further work in the area.

Furthermore, Holton points out, "this is a highly leveraged field." EVIST acts like a catalyst. Its relatively small budget is the major source of funding in the field. University departments, interdisciplinary programs, and publications have been established because of EVIST's existence.

Holton and other scientists stress that EVIST in unique: It is the only source of sustained, long-term support for research in the area. No other federal agency, foundation, or organization will take its place. He and Clifford Grobstein of the University of California, San Diego, chairman of EVIST's Advisory Committee, emphasize that "the abrupt decision to zero out the program"—without consulting the Advisory Committee—"endangers a whole cadre of research." In addition, several scientists note, interdisciplinary projects on ethics and values of science are unlikely to compete effectively for funds in the traditional discipline-oriented NSF program, which is why EVIST was set up in the first place.

Indeed, Boston University's Baram points out that support for research in this area is of great practical importance to society, simple "a good business decision."

Protests over termination of EVIST have come from the Institute of Electrical & Electronics Engineers, AAAS, Society for Computer Simulation, American Philosophical Association, and Association of American Universities, as well as many individual scientists. And congressional aides tell C&EN that there are good prospects for restoration of the program's budget, with support from both Democrats and Republicans.

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